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PHYSIKALISCH-METEOROLOGISCHES OBSERVATORIUM DAVOS
DAVOS-PLATZ, SWITZERLAND

The diurnal and annual variations of the spectral intensity of ultraviolet sky and global radiation

(between 297.5 mμ and 380 mμ)

on cloudless days at Davos, 1590 m a.s.l.

Contract AF 61 (052)-618
Technical Note No. 2

by

PAUL BENER

Project Director: *W. Mörikofer*

Davos-Platz, Switzerland · January 1963

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CONTENTS

SUMMARY

The climatological features of the spectral intensity of ultraviolet sky and global radiation are presented in this paper in the form of hourly values for every month of the year. These figures relate to monthly means of atmospheric ozone and to average conditions of ground reflexion and turbidity during the "winter period" (ground covered with snow) and the "summer period" (ground free from snow). Diagrams showing the diurnal variation of the intensity for various wavelengths and its spectral distribution for different hours of the day are presented for December, March, June and September, which months have high, medium and low monthly means of atmospheric ozone amount. Further diagrams show the annual variation of the intensity for various hours and wavelengths. The latter curves illustrate the combined effect of the annual variation of solar declination, atmospheric ozone and ground reflexion on the intensity of ultraviolet sky and global radiation. The ratio between the vertical component of direct ultraviolet solar radiation and total diffuse radiation is examined in its diurnal and annual variation and in dependence on wavelength. An increase of this ratio with increasing values of solar altitude and wavelength can be stated for all wavelengths between 330 mμ and 370 mμ. The influence of atmospheric ozone on this ratio is shortly discussed.

No climatological means in a strict statistical sense are given; the diurnal and annual variations of the intensity have been computed from the relations between intensity, solar altitude and ozone established in a former Report [1]. A description of the applied procedure and a discussion of the results and their accuracy is given.

P R E F A C E

The knowledge of the ultraviolet radiation incident from sun and sky upon the earth is of vital interest for geophysics as well as for biophysics. This field has therefore been studied for almost half a century at the Davos Observatory. During the first decades integrating methods such as photo-electric cadmium cells have been used as indicator; this procedure has, however, not proved satisfactory for different reasons.

A suitable spectrometer for the measurement of the diffuse sky radiation from the whole hemisphere was therefore developed by Dr. P. Bener, research fellow at the Davos Observatory, and records of the spectral intensity of ultraviolet sky and global radiation have been taken over a period of several years. The results published in three Reports [1,2,3] were first evaluated under the aspect of atmospheric optics and the influence of solar altitude, atmospheric ozone, ground reflexion and turbidity on the intensity was examined.

As a bioclimatological approach is in line with the tradition of the Davos Observatory, the data of our investigation have furthermore been interpreted from the viewpoints of radiation climatology and medical climatology, which are especially interested in the knowledge of the mean conditions of natural ultraviolet radiation and their variations with time. The daily and the annual variations of ultraviolet intensity are therefore studied in the present paper and the relative contributions of ultraviolet direct solar radiation and diffuse radiation to global radiation is examined. In principle the same material was used as in [1], but the period of measurements could be extended and covers for the present report the time from January 1958 until November 1961.

Our spectrometric investigations on ultraviolet radiation have been enabled by various grants. Financial support for the instrumental acquisitions and the development of the equipment was given by the Swiss National Research Foundation, by UNESCO and by the Radiation Commission of the International Association of Meteorology. The necessary subsidy for operating the equipment and for processing the results and especially also for the preparation of the present report was offered by the Cambridge Research Laboratories, OAR, through the European Office, Aerospace Research, United States Air Force.

I wish to express herewith our gratitude to all these organizations which have enabled us to undertake and promote our investigations on ultraviolet radiation.

Davos-Platz, January 1963 W. Mörikofer

LIST OF SYMBOLS

B	Turbidity factor introduced by <u>Schüepp</u> [5]
f	Factor introduced on page 24 and relating to the variations of the intensities H and G which are caused by the daily deviations x of the amount of atmospheric ozone from the monthly means
$G(\lambda,h,X)$	Spectral intensity of ultraviolet global (=sun+sky) radiation, expressed in $Wcm^{-2}m\mu^{-1}$ as a function of λ, h and X
$H(\lambda,h,X)$	Spectral intensity of ultraviolet sky radiation, expressed in $Wcm^{-2}m\mu^{-1}$ as a function of λ, h and X
$G(0.250,\lambda,h)$	Spectral intensity G for an amount X = 0.250 cm of atmospheric ozone
$H(0.250,\lambda,h)$	Spectral intensity H for an amount X = 0.250 cm of atmospheric ozone
$\overline{\Delta G}$	Mean scattering of the intensity G, caused by the average deviation $\pm\sqrt{\overline{x^2}}$ of the daily amounts of atmospheric ozone from the monthly means
$\overline{\Delta H}$	Corresponding scattering of the intensity H
h	Solar altitude
$I(\lambda,h,X)$	Spectral intensity of ultraviolet global or sky radiation, expressed as a function of λ, h and X in $Wcm^{-2}m\mu^{-1}$
λ	Wavelength in $m\mu$
r	Daily deviation of the amount X of atmospheric ozone from the monthly means, expressed in %
S_v	Vertical component of direct ultraviolet solar radiation, expressed in $Wcm^{-2}m\mu^{-1}$
$T_{\lambda h}$	Coefficient in formula (1) page 10, determining the influence of atmospheric ozone on the intensities H and G

T_G	Coefficient $T_{\lambda h}$ for global radiation
T_H	Coefficient $T_{\lambda h}$ for sky radiation
t	Local apparent time (LAT)
X	Daily total amount of atmospheric ozone expressed in terms of a layer in cm N.T.P.
$\bar{X}$	Monthly mean of X
$\bar{\bar{X}}$	Mean value of $\bar{X}$, averaged over the period from 1927 to 1958
x	Daily deviation of the amount X of atmospheric ozone from the monthly mean $\bar{X}$, expressed in cm

INTRODUCTION

A large number of records of the spectral intensity of ultraviolet radiation from the whole sky and from sun + sky (= global radiation) on a horizontal surface have been taken during the period 1958 to 1961 at the Davos Observatory (Switzerland, 1590 m a.s.l., $\varphi = 46^{\circ}48'N$, $\lambda = 9^{\circ}49'E$).

In a former Report [1] which is based on the results obtained until May 1959 the spectral intensity is discussed in dependence on solar altitude, amount of atmospheric ozone, ground reflexion and atmospheric turbidity. Further results, technical improvements and a theoretical discussion are published in two other Reports [2,3]. The present investigation is concerned with the diurnal and annual variation of the intensity and all data obtained from 1958 until November 1961 have been considered.

The values given in this report do not represent climatological means of ultraviolet radiation at Davos in a strict sense of the term. Although altogether 1645 records of sky radiation and 870 records of global radiation have been evaluated, the number of data is not sufficient enough to establish statistical means of intensity for all possible conditions and for every hour of the day throughout the year. Continuous measurements over a much longer period would have been necessary for that purpose. It is however possible to reconstruct the diurnal variation of the average intensity by considering the variation of the principal parameters (solar altitude, ozone, albedo) and their influence on radiation. It is along these lines that the following results have been derived. The procedure applied to this end is restricted to practically cloudless days (cloudiness $\leq$ 1/10 and will be described on the following pages.

1. The derivation of the climatological values

The spectral intensity of ultraviolet sky and global radiation below 330 mμ depends strongly on the amount of atmospheric ozone. An empirical relation

$$\log I(X,\lambda,h) = \log I(0.250,\lambda,h) - T_{\lambda h}(X - 0.250) \qquad (1)$$

was established in Technical Summary Report No.1 [1, p.104 and 124] to state the dependence of the measured intensity $I(X,\lambda,h)$ of ultraviolet sky or global radiation on the amount X of atmospheric ozone expressed in terms of a layer in cm N.T.P. In the present as well as in the former Report the values of X are given in the old scale in use before IGY. The corresponding values according to the new scale would be higher by a factor of 1.34. The designations λ and h stand for wavelength and solar altitude respectively. The intensity $I(0.250,\lambda,h)$ refers to a fixed amount $X = 0.250$ cm of ozone which was arbitrarily chosen as corresponding approximately to the mean annual amount. The coefficients $T_{\lambda h}$ which represent the variation of $\log I(X,\lambda,h)$ per unit of ΔX have been determined in [1] for the wavelengths and solar altitudes chosen for evaluation. Values of $I(0.250,\lambda,h)$ and $T_{\lambda h}$ for sky and for global radiation are given in Tables 30 and 36 of the former Report.

Monthly mean values of the amount of atmospheric ozone should be known for deriving the diurnal variation of the intensity in the course of the year. An average value $\bar{\bar{X}}$ of the monthly means $\bar{X}$ has been computed for every month from the data measured from 1927 to 1958 at the Lichtklimatisches Observatorium Arosa, which is situated in another valley of the Alps at 11 km distance from the Davos Observatory. These averages have been determined from the figures published by <u>G. Perl</u> and <u>H. Dütsch</u> in

"Die 30jährige Aroser Ozonmessreihe"[4]. It is furthermore desirable to know the mean scattering of the daily values X around the monthly means $\bar{X}$. An average value $\sqrt{\overline{x^2}}$ of the deviation $x = X - \bar{X}$ was therefore computed for every month from the data relating to 8 years arbitrarily chosen for that purpose. The monthly means $\bar{\bar{X}}$, the scattering $\sqrt{\overline{x^2}}$ and the mean values of the relative deviation $r = x/\bar{X}$ are given in Table 1.

Table 1. 32 years average values $\bar{\bar{X}}$ of the monthly means of atmospheric ozone at Arosa (Switzerland) computed from the figures published by G. Perl and H. Dütsch [4]. The designations x and r are explained in the text.

	$\bar{\bar{X}}$ cm	$\sqrt{\overline{x^2}}$ cm	$\sqrt{\overline{r^2}}$ %
January	0.245	0.029	12
February	0.261	0.028	11
March	0.269	0.025	9.3
April	0.270	0.023	8.5
May	0.264	0.015	5.7
June	0.250	0.014	5.6
July	0.235	0.012	5.1
August	0.224	0.013	5.8
September	0.211	0.015	7.1
October	0.205	0.017	8.3
November	0.207	0.018	8.7
December	0.223	0.021	9.4

Proceeding from the monthly means $\bar{\bar{X}}$ the spectral intensity of ultraviolet sky and global radiation can be computed for every month by means of the relation (1) provided that the values of $T_{\lambda h}$ and $I(0.25,\lambda,h)$ are known for the wavelengths and solar altitudes in question. While the coefficients $T_{\lambda h}$ given in Tables 30 and 36 of Report [1] will be applied in this paper,

<u>Table 2a:</u> **Spectral intensity of ultraviolet sky radiation H and global radiation G (expressed in $Wcm^{-2}m\mu^{-1}$) for an amount of X = 0.250 cm of atmospheric ozone. <u>Winter conditions.</u> <u>Abbreviations:</u> h = solar altitude; 6.20-10 stands for $6.20 \cdot 10^{-10}$.**

h°	λ	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
0°	H			6.20-10	1.59-9	3.50-9	7.25-9	1.80-8	3.18-8
5°	H			1.37-9	4.79-9	1.32-8	3.18-8	9.10-8	1.99-7
10°	H			3.02-9	1.30-8	4.45-8	1.11-7	3.55-7	7.25-7
15°	H		1.05-9	6.65-9	3.50-8	1.27-7	3.19-7	9.10-7	1.72-6
	G			(4.55-9	3.04-8)	1.31-7	3.30-7	1.12-6	1.87-6
20°	H		2.34-9	1.47-8	8.49-8	3.03-7	6.81-7	1.81-6	3.13-6
	G		(2.00-9	1.33-8)	1.06-7	3.25-7	8.52-7	2.20-6	3.83-6
25°	H		5.20-9	3.26-8	1.89-7	5.80-7	1.24-6	3.03-6	4.74-6
	G		5.90-9	3.51-8	2.48-7	7.08-7	1.65-6	3.75-6	6.38-6
30	H	2.80-9	1.16-8	7.05-8	3.75-7	1.00-6	1.93-6	4.40-6	6.33-6
	G	(2.50-9)	1.56-8	8.75-8	5.22-7	1.30-6	2.66-6	5.80-6	9.12-6
35°	H	4.45-9	2.57-8	1.32-7	5.90-7	1.56-6	2.60-6	5.95-6	7.86-6
	G	5.34-9	3.55-8	1.81-7	8.85-7	2.13-6	3.92-6	8.20-6	1.19-5
40°	H	7.00-9	4.78-8	2.16-7	8.30-7	2.17-6	3.21-6	7.30-6	9.30-6
	G	1.15-8	7.66-8	3.37-7	1.39-6	3.29-6	5.55-6	1.11-5	1.52-5
45°	H	1.13-8	7.30-8	3.14-7	1.10-6	2.73-6	3.87-6	8.45-6	1.08-5
	G	2.44-8	1.38-7	5.80-7	2.04-6	4.70-6	7.20-6	1.45-5	1.88-5
50°	H	1.80-8	1.03-7	4.19-7	1.38-6	3.28-6	4.60-6	9.41-6	1.22-5
	G	4.85-8	2.30-7	9.20-7	2.91-6	6.30-6	9.05-6	1.81-5	2.30-5
55°	H	2.85-8	1.37-7	5.35-7	1.70-6	3.72-6	5.28-6	1.03-5	1.35-5
	G	8.88-8	3.23-7	1.35-6	3.95-6	7.85-6	1.11-5	2.23-5	2.72-5
60°	H	4.50-8	1.79-7	6.61-7	2.02-6	4.10-6	5.85-6	1.10-5	1.47-5
	G	1.45-7	4.15-7	1.85-6	5.20-6	9.40-6	1.32-5	2.60-5	3.15-5
65°	H	7.00-8	2.30-7	8.00-7	2.30-6	4.39-6	6.40-6	1.16-5	1.58-5
	G	2.16-7	4.90-7	2.40-6	6.63-6	1.09-5	1.54-5	2.90-5	3.62-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
6.50-8	9.96-8	2.54-7	5.40-7	7.74-7	9.03-7	9.38-7	9.14-7	8.25-7
3.95-7	6.40-7	1.39-6	2.67-6	3.40-6	3.59-6	3.65-6	4.25-6	4.11-6
1.36-6	2.04-6	3.93-6	6.29-6	7.24-6	7.33-6	7.30-6	8.43-6	7.84-6
2.95-6	4.34-6	7.03-6	1.01-5	1.10-5	1.09-5	1.05-5	1.18-5	1.03-5
3.23-6	4.76-6	8.05-6	1.20-5	1.35-5	1.40-5	1.41-5	1.76-5	1.65-5
5.02-6	6.75-6	9.96-6	1.38-5	1.45-5	1.44-5	1.37-5	1.48-5	1.26-5
5.90-6	8.47-6	1.31-5	1.86-5	2.06-5	2.10-5	2.18-5	2.57-5	2.39-5
7.15-6	8.90-6	1.31-5	1.80-5	1.81-5	1.73-5	1.65-5	1.77-5	1.49-5
9.40-6	1.25-5	1.87-5	2.59-5	2.83-5	2.88-5	2.98-5	3.41-5	3.22-5
9.40-6	1.09-5	1.57-5	2.10-5	2.10-5	1.98-5	1.89-5	2.01-5	1.68-5
1.33-5	1.69-5	2.38-5	3.27-5	3.56-5	3.65-5	3.76-5	4.22-5	4.04-5
1.14-5	1.30-5	1.78-5	2.36-5	2.38-5	2.20-5	2.10-5	2.20-5	1.86-5
1.75-5	2.13-5	2.90-5	3.93-5	4.20-5	4.35-5	4.37-5	4.97-5	4.80-5
1.31-5	1.49-5	1.97-5	2.58-5	2.62-5	2.40-5	2.28-5	2.35-5	2.02-5
2.20-5	2.58-5	3.38-5	4.67-5	4.88-5	5.06-5	5.02-5	5.88-5	5.73-5
1.46-5	1.68-5	2.17-5	2.78-5	2.82-5	2.60-5	2.50-5	2.50-5	2.19-5
2.68-5	3.05-5	3.90-5	5.40-5	5.53-5	5.73-5	5.64-5	6.55-5	6.33-5
1.60-5	1.85-5	2.37-5	2.98-5	3.00-5	2.80-5	2.68-5	2.62-5	2.35-5
3.17-5	3.50-5	4.40-5	6.12-5	6.17-5	6.41-5	6.39-5	7.18-5	6.76-5
1.73-5	2.02-5	2.60-5	3.20-5	3.18-5	2.98-5	2.85-5	2.72-5	2.51-5
3.63-5	3.95-5	4.82-5	6.80-5	6.60-5	7.00-5	6.99-5	7.60-5	7.06-5
1.81-5	2.19-5	2.80-5	3.40-5	3.32-5	3.15-5	3.00-5	2.80-5	2.67-5
4.10-5	4.45-5	5.25-5	7.40-5	6.95-5	7.50-5	7.55-5	7.95-5	7.20-5
1.90-5	2.34-5	3.00-5	3.65-5	3.47-5	3.30-5	3.15-5	2.87-5	2.80-5
4.45-5	4.95-5	5.60-5	7.90-5	7.30-5	8.00-5	8.00-5	8.20-5	7.23-5

Table 2b: Spectral intensity of ultraviolet sky radiation H and global radiation G (expressed in $Wcm^{-2}m\mu^{-1}$) for an amount of X = 0.250 cm of atmospheric ozone. Summer conditions. Abbreviations: h = solar altitude; 2.30-10 stands for $2.30 \cdot 10^{-10}$.

h°	λ	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
0°	H			2.30-10	6.67-10	1.80-9	3.70-9	9.80-9	1.94-8
5°	H			5.60-10	2.02-9	7.60-9	1.73-8	5.30-8	1.17-7
10°	H			1.38-9	6.00-9	2.24-8	5.52-8	2.00-7	4.34-7
15°	H		6.02-10	3.36-9	1.70-8	6.08-8	1.66-7	5.30-7	1.12-6
	G			3.41-9	2.31-8	7.60-8	2.03-7	6.60-7	1.40-6
20°	H		1.65-9	8.30-9	4.79-8	1.65-7	4.06-7	1.14-6	2.18-6
	G		(1.51-9)	8.80-9	6.10-8	1.91-7	4.45-7	1.38-6	2.40-6
25°	H		4.39-9	2.02-8	1.19-7	3.75-7	8.30-7	1.95-6	3.36-6
	G		(3.95-9)	2.21-8	1.44-7	4.05-7	9.00-7	2.52-6	3.99-6
30°	H	1.70-9	1.08-8	5.00-8	2.50-7	7.00-7	1.33-6	2.93-6	4.55-6
	G	(1.42-9	1.05-8)	5.75-8	3.12-7	8.00-7	1.67-6	4.25-6	6.37-6
35°	H	3.30-9	2.32-8	1.18-7	4.42-7	1.10-6	1.86-6	3.93-6	5.65-6
	G	3.75-9	2.65-8	1.33-7	5.93-7	1.50-6	2.75-6	6.41-6	9.10-6
40°	H	6.20-9	4.28-8	2.15-7	7.26-7	1.58-6	2.45-6	5.00-6	6.80-6
	G	8.81-9	6.05-8	2.61-7	1.06-6	2.60-6	4.18-6	9.00-6	1.23-5
45°	H	1.14-8	7.10-8	3.05-7	1.01-6	2.05-6	3.08-6	6.00-6	7.80-6
	G	1.78-8	1.13-7	4.40-7	1.65-6	3.85-6	5.70-6	1.14-5	1.52-5
50°	H	2.00-8	1.02-7	3.92-7	1.27-6	2.49-6	3.71-6	6.70-6	8.69-6
	G	3.20-8	1.87-7	6.42-7	2.33-6	4.90-6	7.20-6	1.35-5	1.76-5
55°	H	3.14-8	1.34-7	4.73-7	1.48-6	2.80-6	4.38-6	7.30-6	9.40-6
	G	5.20-8	2.87-7	8.60-7	3.05-6	5.70-6	8.55-6	1.52-5	1.97-5
60°	H	4.40-8	1.63-7	5.48-7	1.68-6	3.04-6	4.95-6	7.80-6	1.00-5
	G	7.65-8	4.10-7	1.10-6	3.78-6	6.30-6	9.90-6	1.67-5	2.13-5
65	H	5.60-8	1.87-7	6.22-7	1.87-6	3.21-6	5.50-6	8.20-6	1.07-5
	G	1.03-7	5.40-7	1.35-6	4.40-6	6.65-6	1.12-5	1.80-5	2.28-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
3.45-8	5.66-8	1.55-7	3.31-7	5.10-7	6.26-7	6.45-7	7.45-7	6.73-7
2.40-7	4.08-7	9.63-7	1.90-6	2.32-6	2.93-6	3.03-6	3.47-6	3.35-6
9.00-7	1.31-6	2.54-6	4.54-6	5.29-6	6.05-6	6.25-6	6.94-6	6.45-6
1.86-6	2.65-6	4.51-6	7.54-6	8.29-6	8.84-6	8.86-6	9.85-6	8.59-6
2.34-6	3.27-6	5.70-6	8.50-6	1.01-5	1.16-5	1.22-5	1.66-5	1.55-5
3.10-6	4.46-6	6.80-6	1.04-5	1.10-5	1.13-5	1.11-5	1.25-5	1.06-5
3.86-6	4.95-6	8.15-6	1.32-5	1.47-5	1.62-5	1.72-5	2.23-5	2.08-5
4.58-6	6.40-6	8.80-6	1.28-5	1.34-5	1.36-5	1.31-5	1.49-5	1.25-5
6.00-6	7.40-6	1.13-5	1.93-5	2.02-5	2.20-5	2.30-5	2.90-5	2.74-5
6.03-6	8.40-6	1.07-5	1.48-5	1.53-5	1.54-5	1.47-5	1.70-5	1.42-5
8.80-6	1.09-5	1.57-5	2.48-5	2.62-5	2.87-5	2.95-5	3.62-5	3.47-5
7.50-6	1.00-5	1.24-5	1.64-5	1.68-5	1.70-5	1.62-5	1.87-5	1.58-5
1.25-5	1.54-5	2.12-5	2.99-5	3.17-5	3.50-5	3.63-5	4.38-5	4.23-5
8.90-6	1.13-5	1.42-5	1.81-5	1.83-5	1.85-5	1.72-5	1.99-5	1.71-5
1.67-5	2.01-5	2.73-5	3.50-5	3.70-5	4.02-5	4.20-5	5.05-5	4.92-5
1.01-5	1.25-5	1.58-5	1.93-5	1.92-5	1.94-5	1.82-5	2.12-5	1.86-5
2.09-5	2.40-5	3.27-5	3.95-5	4.15-5	4.55-5	4.64-5	5.51-5	5.32-5
1.13-5	1.35-5	1.73-5	2.03-5	1.99-5	2.00-5	1.90-5	2.18-5	1.96-5
2.40-5	2.75-5	3.72-5	4.40-5	4.60-5	4.89-5	5.05-5	5.92-5	5.58-5
1.23-5	1.45-5	1.87-5	2.13-5	2.05-5	2.04-5	1.97-5	2.27-5	2.09-5
2.69-5	3.05-5	4.13-5	4.82-5	5.00-5	5.15-5	5.35-5	6.25-5	5.81-5
1.30-5	1.50-5	2.01-5	2.21-5	2.12-5	2.08-5	2.03-5	2.32-5	2.21-5
2.93-5	3.30-5	4.50-5	5.20-5	5.38-5	5.35-5	5.63-5	6.55-5	5.94-5
1.35-5	1.55-5	2.13-5	2.27-5	2.19-5	2.12-5	2.08-5	2.37-5	2.31-5
3.17-5	3.55-5	4.82-5	5.60-5	5.75-5	5.50-5	5.90-5	6.80-5	6.00-5

Table 3a: The coefficient $T_{\lambda h}$ (expressed in cm^{-1}) for ultraviolet sky radiation. h = solar altitude

λ [mμ] \ h	0°	5°	10°	15°	20°	25°	30°	35°	40°	50-66°
297.5								9.0	8.6	8.2
300.0				12	9.9	9.4	8.6	8.2	6.2	5.5
302.5		8.2	9.4	12	9.9	9.0	8.6	7.8	4.9	4.3
305.0	7.5	7.5	9.4	12	9.0	7.2	6.9	6.2	4.0	3.1
307.5	6.4	6.9	9.0	10	7.8	5.7	5.5	4.8	3.4	2.5
310.0	5.3	6.2	8.2	8.6	6.2	4.4	4.3	3.6	2.6	1.9
312.5	3.7	4.9	6.4	5.9	4.0	2.8	2.9	2.2	1.7	1.3
315.0	2.4	3.9	4.1	4.0	2.5	1.9	2.0	1.5	1.1	0.8
317.5	2.1	3.6	3.9	3.6	2.3	1.7	1.9	1.3	1.1	0.8
320.0	1.8	3.2	3.2	2.9	1.9	1.5	1.6	1.1	0.9	0.7
325.0	1.2	2.4	2.0	1.9	1.3	1.0	1.1	0.8	0.6	0.5
330.0	0.3	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1

Table 3b: The coefficient $T_{\lambda h}$ (expressed in cm^{-1}) for ultraviolet global radiation. h = solar altitude

λ [mμ] \ h	15°	20°	25°	30°	40°	45°	50-66°
297.5				12	9.9	13	15
300.0		12	12	12	9.4	9.0	12
302.5	11	12	11	10	7.8	6.9	9.9
305.0	10	10	8.6	7.5	6.2	5.5	7.5
307.5	9.4	8.6	6.7	5.3	4.9	4.4	5.9
310.0	7.8	6.2	5.1	3.6	3.9	3.6	4.8
312.5	5.1	3.7	3.4	2.0	2.6	2.4	3.5
315.0	2.9	2.4	2.2	1.2	1.8	1.7	2.5
317.5	2.6	2.1	2.0	1.1	1.6	1.5	2.3
320.0	2.1	1.8	1.8	0.9	1.4	1.4	2.0
325.0	1.5	1.2	1.2	0.6	1.0	1.0	1.5
330.0	0.3	0.2	0.3	0.1	0.2	0.2	0.3

new averages for I(0.250,λ,h) based on all results obtained until 1961 have been determined for the present investigation. These figures are given in Tables 2a-b and 3a-b for winter and summer conditions and for sky and global radiation respectively. Some remarks concerning these tables may be added.

The time during which the sun is higher than 55° is limited to a few hours per day during some summer months. In otherwise fair weather conditions cumuli are then likely to develop near noon after a cloudless morning. Only a limited number of records could therefore be taken in practically cloudless conditions for h $\geq$ 55°. These data relate furthermore to a rather narrow interval of ozone variations. It was therefore not possible to establish reliable values of $T_{\lambda h}$ for solar altitudes above 50°. As an approximation the figures obtained for 50° solar altitude will be applied up to h = 66°, which is the highest solar elevation for the latitude of Davos.

The values of the intensity I(0.250,λ,h) have been derived in the manner described in Chapter 4 and 5 of Report [1]. A short summary of the procedure may be in place here.

The spectrum was normally scanned from about 290 mμ to 380 mμ with an effective spectral bandwidth varying from 0.9 mμ at 295 mμ to 2.2 mμ at 380 mμ. The records show a more or less smoothed picture of the Fraunhofer structure. For the purpose of our investigation it was not thought necessary to evaluate the spectra in every detail. Up to 325 mμ the spectral intensity was determined for the wavelengths 297.5, 300.0, 302.5 .....320.0 and 325.0 mμ. In the region above 325 mμ the mean intensity averaged over bands of 10 mμ and centred at 330, 340,...380 mμ was determined from the records. The intensities measured in cloudless or nearly cloudless conditions (cloudiness $\leq$ 1/10) were then interpolated for round values of solar altitude. To this end the values determined for each wavelength and measured on the same day were plotted on a logarithmic scale as a function of solar altitude and

read in steps of 2.5 mμ from the graph. A large number of values for the intensity relating to different amounts of atmospheric ozone was obtained in that manner. Every value relating to the same wavelength and solar altitude was then reduced to X = 0.250 cm by means of relation (1) and the coefficients $T_{\lambda h}$. The average of the reduced figures was taken for the intensity I(0.250,λ,h). For 340 mμ $\leqq \lambda \leqq$ 380 mμ practically no absorption by ozone must be considered and no reduction to X = 0.250 cm applied in this case. In this wavelength region the figures for I(0.250,λ,h) represent the averages of all values obtained for the same wavelength and solar altitude.

Ground reflexion is another important parameter which influences ultraviolet sky and global radiation, and the effect of the increased albedo produced by the snow cover during the winter period can clearly be seen in the intensity values. The intensities measured during the winter period when the ground was entirely covered with snow and those obtained in summer were therefore separately interpolated and averaged and mean values for the intensity I(0.250,λ,h) relating to both periods have thus been determined. It was then assumed that winter conditions prevail in the region of Davos from the beginning of November until the end of April and the final results derived for this period are based on the intensities measured in winter conditions. Summer conditions were on the other hand assumed for the remaining period.

No clear relation between the intensity of ultraviolet sky and global radiation and turbidity could on the other hand be established in the former Report [1] when the intensity was examined as a function of the turbidity factor B introduced by W. Schüepp [5]. Furthermore, no systematic difference between the intensities relating to morning and afternoon respectively could be stated. The averages for I(0.250,λ,h) include therefore indiscriminately the values obtained in the morning or

the afternoon as well as in different turbidity conditions. It must however be mentioned that the latter is normally low at the altitude region of Davos except in rare cases.

Taking account of the monthly means $\bar{\bar{X}}$ of atmospheric ozone and applying the figures for $I(0.250,\lambda,h)$ and $T_{\lambda h}$ the intensities $H(\bar{\bar{X}},\lambda,h)$ and $G(\bar{\bar{X}},\lambda,h)$ of ultraviolet sky and global radiation were computed according to relation (1) for every month and for the wavelengths and the solar altitudes considered. The values of $H(\bar{\bar{X}},\lambda,h)$ and $G(\bar{\bar{X}},\lambda,h)$ were then plotted for every wavelength as a function of solar altitude and an approximating curve was drawn through the points of every graph. Diagrams representing smoothed values of the intensity in dependence of solar altitude were thus obtained for every wavelength and every month.

Time had then to be introduced in place of solar altitude for the climatological representation. The 16th day was taken as representative for every month except in the case of June and December where the 11th day was chosen. The values of solar altitude relating to full and half hours on these days were then determined for the latitude of Davos (see Table 4). By these figures the intensity corresponding to the various hours of the representative days could be read from the diagrams for $H(h,\lambda,\bar{\bar{X}})$ and $G(h,\lambda,\bar{\bar{X}})$ respectively.

The results thus obtained are represented in Tables 5-16 (see Annex) for every month of the year. The diagrams of Figs. 1a-d to 6a-d show the diurnal and annual variation of the intensity as well as its spectral distribution. The records taken from January to November 1961 cover the wavelength region between 297.5 mμ and 415 mμ and the results obtained during this period have been applied to extend the spectra shown in Figs. 3a-d and 4a-d up to 410 mμ.

Table 4. Hourly values of solar altitude for the latitude of Davos. LAT = local apparent time

LAT / Month:	Jan.	Febr.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
4.00/20.00					-4.9	-1.7	-3.0					
4.30/19.30					-0.6	2.6	1.3	-4.6				
5.00/19.00				-2.7	4.0	7.0	5.8	0.1				
5.30/18.30			-6.5	2.2	8.8	11.7	10.5	5.0	-3.1			
6.00/18.00			-1.3	7.3	13.8	16.6	15.4	10.0	2.1	-6.4		
6.30/17.30		-3.9	3.8	12.4	18.8	21.6	20.5	15.1	7.2	-1.3		
7.00/17.00	-5.4	1.0	8.8	17.6	23.9	26.7	25.5	20.2	12.3	3.6	-3.8	
7.30/16.30	-0.9	5.7	13.8	22.6	29.0	31.8	30.7	25.4	17.4	8.5	0.8	-2.6
8.00/16.00	3.4	10.2	18.6	27.7	34.2	36.9	35.8	30.4	22.2	13.1	5.1	1.6
8.30/15.30	7.4	14.5	23.2	32.5	39.2	42.0	40.9	35.4	26.9	17.5	9.2	5.6
9.00/15.00	11.0	18.5	27.4	37.1	44.1	47.0	45.8	40.1	31.3	21.5	12.9	9.1
9.30/14.30	14.2	22.0	31.3	41.4	48.7	51.8	50.5	44.5	35.4	25.2	16.2	12.3
10.00/14.00	17.0	25.0	34.7	45.3	53.0	56.2	54.9	48.6	38.9	28.3	19.1	15.0
10.30/13.30	19.2	27.5	37.5	48.6	56.7	60.2	58.8	52.0	41.9	30.9	21.4	17.2
11.00/13.00	20.9	29.3	39.6	51.1	59.6	63.4	61.9	54.7	44.2	32.8	23.0	18.8
12.00/12.00	22.2	30.8	41.5	53.2	62.2	66.3	64.6	57.0	46.1	34.4	24.4	20.1

2. Remarks on the accuracy of the results

The results presented in this paper are based on the intensities $H(0.250,\lambda,h)$ and $G(0.250,\lambda,h)$ given in Tables 2a-b for winter and summer conditions respectively. As mentioned in section 1 these values are the averages of the interpolated and reduced intensities which relate to the various days when records were taken. The mean deviation of the daily values from the averages $H(0.250,\lambda,h)$ and $G(0.250,\lambda,h)$ can therefore be taken as a rough measure for the accuracy of the final results. The latter scattering amounts in the mean over all solar altitudes to ± 28 % between 300 mμ and 305 mμ, to 17 % for 310 mμ and to ± 13 % between 315 mμ and 325 mμ. For wavelengths $\lambda \geqq 330$ mμ the scatter does not vary systematically with wavelength and amounts to ± 25 % for $h=0°$ and to 9 % - 14 % for higher solar altitudes.

This scattering is partly caused by errors of measurement and partly by errors introduced by the reduction of the daily values to $X = 0.250$ cm. Furthermore the natural variation of the intensity in dependence of turbidity and of the varying albedo during the winterperiod must be taken into account.

The measuring accuracy is discussed in Chapter 2 of Report [1] where all kinds of sources of error are considered. The resulting statistical error of measurement is estimated in Table 13 of [1] for round values of wavelength and solar altitude. It amounts to between ± 5 % and ± 19 % except for $\lambda \leqq 305$ mμ and $h \leqq 10°$ in which cases the error is occasionally larger.

A considerable part of the scatter found below 330 mμ is caused by errors involved in the reduction of the intensity to an ozone amount of $X = 0.250$ cm. The empirical relation (1) which has been applied for the reduction and the derivation of the coefficients $T_{\lambda h}$ are discussed in the sections 4.3 and 5.3 of

Report [1]. It was not possible to establish the coefficients $T_{\lambda h}$ very accurately. This is partly due to the fact that only the total amount X of atmospheric ozone was considered in relation (1), whereas no regard has been taken to its vertical distribution. The reduction of the intensity to X = 0.250 cm or to the various monthly means $\bar{\bar{X}}$ works therefore only up to a certain approximation.

When considering the large scattering in the daily values of H(0.250,λ,h) and G(0.250,λ,h) below 305 mμ it must be taken into account that the influence of ozone absorption is very strong in this wavelength region. The average value of the coefficients $T_{\lambda h}$ amounts for sky radiation and for 300 mμ $\leq \lambda \leq$ 305 mμ to 7.9 cm^{-1}. The annual variations $\Delta \bar{\bar{X}}$ = 0.065 cm of the monthly means $\bar{\bar{X}}$ cause thus variations of intensity by a factor of 3.3. The corresponding factor for global radiation is 4.1.

The records of sky and global radiation were not always made alternately during the whole day. The measured intensities of these radiation fluxes relate therefore in many cases to different times of the day or even to different days. The average values derived from the two sets of data do therefore not correspond to the same number of days; in this sense the data are not homogeneous.

The coefficients $T_{\lambda h}$ have been determined separately for sky and global radiation. For $\lambda \leq$ 305 mμ and $15^\circ \leq h \leq 30^\circ$ lower values were obtained in some cases for the reduced intensity G(0.250,λ,h) of global radiation than for the corresponding intensity H(0.250,λ,h) of sky radiation. Those values in Table 2a-b are put in brackets. The same applies for the values in Tables 5-16 (see Annex), which represent the diurnal variation of the intensity for every month of the year. These incon-

sistencies are partly caused by some inhomogeneity of the original data mentioned above, partly by errors involved in the reduction to $X = 0.250$ cm. Global and sky radiation differ by the contribution of the component of direct solar radiation. For lower solar altitudes and shorter wavelengths the latter is only a small fraction of the sky radiation, and it may then happen that the errors which are introduced by the reduction are larger than the vertical component of the direct solar radiation. Discrepancies of this kind would also be possible, if the original intensities G and H were better correlated than it is the case with the data available.

Some general remarks regarding the accuracy may be added: The reliability of our results for $\lambda < 330$ mμ depends much on the accuracy with which the influence of ozone can be taken into account. It would be desirable for future work in this field, if a more reliable relation between sky radiation and the total amount as well as the vertical distribution of atmospheric ozone could be established. The intensity of direct solar radiation is on the other hand rather well known as a function of X. More accurate values of global radiation could be obtained for the critical intervals of solar altitude and wavelength by measuring direct solar radiation separately and adding its vertical component to the intensity of sky radiation.

3. The scattering of the daily values around the monthly means

The results presented in Tables 5 to 16 (see Annex) and in the diagrams of Fig. 1 a-d to 6 a-d relate to mean conditions of solar altitude and atmospheric ozone during the different months of the year. The annual variation of ground reflexion has been taken into account in a rather summary way by considering a summer and winter period separately. The same is valid to a certain degree for turbidity. The actual values of intensity vary irregularly in dependence on the daily variations of these parameters. Only the mean scattering of the intensity produced by the daily changes of atmospheric ozone will be considered here. The influence of casual variations of albedo during the winter and the summer period is discussed in section 3.1.3 of Report [1].

The deviations $x = X - \bar{X}$ of the daily amounts of atmospheric ozone from the monthly means cause variations of intensity by factors of $f = \text{num log} \pm x \, T_{\lambda h}$. Proceeding from the average deviations $\pm\sqrt{\overline{x^2}}$ given in Table 1 the factor f was computed for round values of wavelength and solar altitude and interpolated for the different hours of the day. The mean scattering of the intensity which corresponds to the various values of f is given in Table 17 for four selected months and for full hours of the day. These figures show the strong dependence of ultraviolet intensity at shorter wavelengths on the daily amount of atmospheric ozone. Mean scatterings up to + 83 %/- 45 % and + 100 %/-50 % are found for March and for sky and global radiation respectively.

Table 17. The averages $\overline{\Delta H}$ and $\overline{\Delta G}$ of the daily deviations of the intensity from the monthly means, separately for H and G and expressed in %.

December

LAT		λ: 297.5	300.0	305.0	310.0	315.0	320.0	325.0
8.00/15.00	H			+44 -30	+30 -24	+15 -13	+11 -10	+ 8 - 7
9.00/15.00	H			+55 -35	+46 -32	+22 -18	+17 -14	+10 - 9
10.00/14.00	H		+79 -44	+79 -44	+51 -34	+21 -18	+15 -13	+10 - 9
	G		- -	+62 -38	+46 -31	+15 -13	+11 -10	+ 8 - 7
11.00/13.00	H		+65 -39	+60 -37	+39 -28	+15 -13	+11 -10	+ 7 - 7
	G		- -	+62 -38	+38 -27	+13 -11	+ 9 - 9	+ 6 - 6
12.00/12.00	H		+61 -38	+54 -35	+35 -26	+13 -11	+10 - 9	+ 6 - 6
	G		+79 -44	+62 -38	+35 -26	+12 -11	+ 9 - 8	+ 6 - 6

March

LAT	λ:	297.5	300.0	305.0	310.0	315.0	320.0	325.0
7.00/17.00	H			+68 -40	+57 -36	+26 -21	+20 -17	+13 -11
8.00/16.00	H		+83 -45	+77 -43	+49 -33	+18 -15	+14 -12	+ 9 - 8
	G		- -	+78 -44	+47 -32	+16 -14	+12 -10	+ 8 - 7
9.00/15.00	H		+68 -41	+50 -33	+29 -22	+12 -10	+10 - 9	+ 7 - 6
	G		+100 -50	+59 -37	+28 -22	+10 - 9	+ 8 - 7	+ 5 - 5
10.00/14.00	H		+60 -38	+43 -30	+23 -19	+ 9 - 8	+ 7 - 6	+ 5 - 5
	G	+89 -47	+86 -46	+49 -33	+24 -19	+ 9 - 8	+ 6 - 6	+ 4 - 4
11.00/13.00	H	+64 -39	+44 -31	+27 -21	+16 -14	+ 7 - 6	+ 5 - 5	+ 4 - 3
	C	+78 -44	+73 -42	+43 -30	+25 -20	+11 -10	+ 8 - 7	+ 6 - 5
12.00/12.00	H	+63 -38	+42 -30	+25 -20	+15 -13	+ 7 - 6	+ 5 - 5	+ 3 - 4
	G	+86 -46	+71 -41	+41 -29	+24 -20	+11 -10	+ 8 - 7	+ 6 - 5

June

LAT	λ:	297.5	300.0	305.0	310.0	315.0	320.0	325.0
5.00/19.00	H			+30 -24	+26 -21	+13 -12	+11 -10	+ 7 - 6
6.00/18.00	H		+44 -31	+43 -30	+29 -22	+12 -11	+ 9 - 8	+ 5 - 5
	G			+38 -28	+27 -21	+ 9 - 8	+ 6 - 6	+ 5 - 4
7.00/17.00	H		+34 -25	+26 -20	+15 -13	+ 6 - 6	+ 5 - 4	+ 3 - 3
	G		+47 -32	+30 -23	+16 -14	+ 6 - 6	+ 5 - 5	+ 3 - 3
8.00/16.00	H	+33 -25	+27 -21	+19 -16	+11 -10	+ 5 - 5	+ 4 - 3	+ 3 - 2
	G	+41 -29	+39 -28	+24 -19	+13 -12	+ 5 - 5	+ 4 - 4	+ 3 - 3
9.00/15.00	H	+31 -30	+20 -17	+11 -10	+ 7 - 7	+ 3 - 3	+ 2 - 2	+ 2 - 2
	G	+55 -35	+43 -28	+26 -20	+14 -12	+ 7 - 6	+ 6 - 5	+ 4 - 4
10.00/14.00	H	+30 -32	+19 -16	+10 - 9	+ 6 - 6	+ 3 - 3	+ 2 - 2	+ 2 - 2
	G	+62 -38	+47 -32	+27 -21	+17 -14	+ 8 - 8	+ 7 - 6	+ 5 - 5
11.00/13.00	H	+30 -32	+19 -16	+10 - 9	+ 6 - 6	+ 3 - 3	+ 2 - 2	+ 2 - 2
	G	+62 -38	+47 -32	+27 -21	+17 -14	+ 8 - 8	+ 7 - 6	+ 5 - 5
12.00/12.00	H	+30 -32	+19 -16	+10 - 9	+ 6 - 6	+ 3 - 3	+ 2 - 2	+ 2 - 2
	G	+62 -38	+47 -32	+27 -21	+17 -14	+ 8 - 8	+ 7 - 6	+ 5 - 5

September

LAT	λ:	297.5	300.0	305.0	310.0	315.0	320.0	325.0
6.00/18.00	H			+30 -23	+22 -18	+11 -10	+ 8 - 8	+ 5 - 5
7.00/17.00	H			+43 -31	+34 -25	+15 -13	+11 -10	+ 8 - 7
8.00/16.00	H		+40 -28	+33 -24	+17 -17	+ 8 - 7	+ 6 - 6	+ 4 - 4
	G		+51 -34	+38 -28	+22 -18	+ 9 - 8	+ 6 - 6	+ 4 - 4
9.00/15.00	H		+34 -26	+26 -21	+15 -13	+ 6 - 6	+ 5 - 5	+ 4 - 4
	G	+50 -33	+49 -33	+29 -22	+13 -12	+ 4 - 4	+ 3 - 3	+ 2 - 2
10.00/14.00	H	+32 -26	+26 -20	+17 -14	+10 - 9	+ 4 - 4	+ 3 - 3	+ 2 - 2
	G	+42 -30	+39 -28	+25 -20	+14 -12	+ 6 - 6	+ 5 - 5	+ 3 - 3
11.00/13.00	H	+32 -25	+23 -18	+13 -12	+ 8 - 7	+ 3 - 3	+ 3 - 3	+ 2 - 2
	G	+51 -33	+36 -26	+22 -18	+15 -13	+ 7 - 7	+ 6 - 6	+ 3 - 3
12.00/12.00	H	+32 -25	+22 -18	+12 -11	+ 8 - 7	+ 3 - 3	+ 3 - 3	+ 2 - 2
	G	+57 -35	+39 -27	+23 -18	+16 -14	+ 7 - 6	+ 6 - 6	+ 3 - 4

4. Discussion of the climatological results

4.1. The diurnal and annual variation and the spectral distribution of the intensity

The general results of this investigation are represented in Tables 5 to 16 (see Annex), which contain the spectral intensities of ultraviolet sky and global radiation for every month of the year. The diagrams of Figs. 1 a-d through 6 a-d show the diurnal and annual variation as well as the spectral distribution of the intensity for December, March, June, and September. These months cover periods of maximum, medium and minimum solar altitude; March and September correspond furthermore to high and low values of the monthly means of atmospheric ozone.

For solar altitudes $> 10^{\circ}$ the mean spectral intensity does not vary much between 330 mμ and 390 mμ and the curves obtained for the diurnal and annual variation of the intensity in this wavelength region partly cross each other. The hatched bands in the Figs. 1 a-d, 2 a-d and 5 a-d, 6 a-d represent the upper and lower limit of intensity obtained for 340 mμ $\leq \lambda \leq$ 380 mμ.

Sky radiation varies rapidly at hours with low sun in the morning and the afternoon, as can be seen from the curves in Figs. 1 a-d. Depending on wavelength the variations of intensity cover up to several orders of magnitude. The same applies for global radiation (Figs. 2 a-d) with the exception of the period between November and February when global radiation exists only for a few hours daily. For orographical reasons solar altitude does not change much at Davos between sunrise and sunset during this period and the diurnal variations of global intensity are then correspondingly small.

The diagrams Figs. 3a-d and 4a-d show the spectral distribution of ultraviolet sky and global radiation for various hours of the day. For $\lambda \geq 330$ mμ these curves give mean values of intensity averaged over intervals of 10 mμ. As mentioned above the variations of the mean spectral intensity between 330 mμ and 390 mμ are relatively small, especially for hours with higher solar altitudes. This plateau which from 390 mμ towards longer wavelengths is followed by a further increase, is a consequence of a similar trend in the mean extraterrestrial solar spectrum. Another characteristic feature of these spectra is the sharp drop of intensity below 330 mμ. It is due to the rapidly increasing absorption by atmospheric ozone and to a lesser degree to the decrease of the extraterrestrial solar intensity towards shorter wavelengths. At a certain wavelength which depends on the amount of ozone, on solar altitude and on the sensitivity of the instrument the intensity becomes too low to be measured with any accuracy. The short-wave limit where the spectrum is cut off by ozone absorption lies for the applied spectrometer near 295 mμ; this limit relates to sky and global spectra measured at Davos with high solar altitude.

It is furthermore of interest to consider the variation of the intensity in the course of the year as represented in Figs. 5 a-d and 6 a-d for sky and global radiation respectively. These curves show the combined effect of the annual variation of solar altitude, atmospheric ozone and albedo. The variation of atmospheric ozone and solar altitude during the year is given in Tables 1 and 4 respectively. As to the changes of ground reflexion it has been assumed (see p. 18) that winter conditions prevail from November to April. Summer conditions have been assumed for the remaining months.

The intensity of ultraviolet <u>sky radiation</u> increases from <u>January to April</u> with increasing solar altitude. The monthly means of atmospheric ozone increase during this period as well,

which trend counteracts the effect of the rising sun. The increase of intensity during the first months of the year becomes gradually steeper for the curves relating to t = 12.00, 10.00, 8.00 and 6.00 or to the corresponding hours in the afternoon, which will not be especially mentioned further-on. This is due to the fact that the gradient of the curves which represents the intensity in dependence of solar altitude increases towards lower solar altitudes.

From April to May ground reflexion changes to summer conditions while solar altitude is further increasing. The monthly mean of ozone reaches its annual maximum in April and diminishes in May. The influence of the decreased albedo can be seen in the trend of the curves relating to $\lambda \geq 310$ mμ and to the hours between 12.00 and 8.00. The intensities for t = 12.00 and 10.00 drop from April to May for wavelengths $\lambda \geq 315$ mμ. The same is true for the intensity corresponding to t = 8.00 and $\lambda \geq 320$ mμ. The effect of the lower ground reflexion prevails in these cases.

During the period from May to July solar altitude reaches a flat maximum in June while the average amount $\bar{X}$ of ozone diminishes from 0.264 cm to 0.235 cm. Because of the latter decrease the maximum of intensity is shifted or extended to July, except for the intensity relating to t = 6.00 and $\lambda \geq 315$ mμ. Atmospheric ozone decreases further from July to October and reaches its annual mimimum in October. This trend counteracts the effect of the decreasing solar altitude during this period.

Ground reflexion changes in November to winter conditions while ozone does not yet vary essentially from October to November. The effect of the higher albedo can be seen in the trend of the curves corresponding to $\lambda \geq 310$ mμ and to t = 12.00 and 10.00. For 325 mμ and 330 mμ and for t = 12.00

the effect of the step in albedo prevails and the intensity increases in spite of the decreasing solar altitude. No corresponding influence of ground reflexion is recognizable in the curves of Fig. 3c, which relate to τ = 8.00. This can be explained by the fact that solar altitude is low in November at these hours and its influence on the intensity therefore stronger than for higher elevations.

The monthly means of ozone increase from 0.207 cm to 0.245 cm between November and January and the annual minimum of intensity is shifted or extended from December to January for shorter wavelengths. For longer wavelengths the influence of solar altitude prevails and the annual minimum is reached in December.

Apart from minor differences the diagrams of Fig. 6 a-d for the annual variation of ultraviolet global radiation show features similar to those for ultraviolet sky radiation: After the increase of intensity during the first months of the year the change of albedo in May can be seen in the trend of the curves relating to t = 12.00 through 8.00 and $\lambda \geq$ 305 mμ or $\geq$ 310 mμ. In consequence of the decreasing monthly means of atmospheric ozone the annual maximum of global radiation for t = 12.00 and 10.00 is extended or shifted from June to July. The same applies for the curves relating to t = 8.00 and 6.00 and for $\lambda \geq$ 315 mμ and λ = 310 mμ respectively. The following decrease in intensity is to some extent diminished by the seasonal decrease of the monthly means of ozone, as it is the case for sky radiation. The effect of the higher albedo in November is recognizable in the trend of the curves for t = 12.00 and 10.00 and for $\lambda \geq$ 305 mμ. A shift or extension of the annual minimum of ultraviolet global radiation from December to January which is similar to that found for sky radiation occurs in the curves for the shorter wavelengths.

The curves in Figs. 6c and 6d for t = 8.00 and 6.00 cover only a limited period of several months; for the remaining months the sun is below the natural horizon at these hours.

4.2. The ratio between the vertical component of direct solar radiation and the intensity of sky radiation in the ultraviolet

Global radiation G and sky radiation H differ by the vertical component $S_v = G - H$ of direct solar radiation. It is well known [6,7] that for shorter wavelengths and lower solar altitudes this component amounts only to a relatively small fraction of the intensity of the diffuse sky radiation. Table 18 (see p.34) gives as an example theoretical values of the ratio S_v/H for a Rayleigh atmosphere. These figures which relate to summer conditions (with an assumed albedo of 0.15) and to the altitude of Davos, increase rapidly with increasing solar altitude and towards longer wavelengths.

The actual ratios S_v/H which can for example be derived from the measured values of G and H depend furthermore on atmospheric ozone, turbidity and ground reflexion and may vary from day to day. A scattering between ± 7 % and ± 12 % was found in a certain case for various wavelengths and in the average over all solar altitudes considered. This scattering relates to the results obtained on six days when records of sky and global radiation had been made alternately.

It has been mentioned in section 2 that our results on sky and global radiation relate partly to different days and are therefore not strictly correlated to each other. These data are thus not so well suited for a close examination of the ratio S_v/H. In fact the ratios derived from the climatological results given in Tables 5 to 16 (see Annex) show some irregularities when plotted as a function of wavelength and solar altitude. Only mean values averaged over intervals of 10 mμ and 20 mμ respectively will therefore be considered here.

The diagram in Fig. 7 shows as an example the <u>diurnal variation</u> of S_v/H for <u>June</u>. These curves which are based on the figures given in Tables 5 to 16 represent the mean trend of the ratio

Table 18. Theoretical values of the ratio S_v/H between the vertical component S_v of direct solar radiation and the intensity H of sky radiation, for a Rayleigh atmosphere and an assumed albedo of 0.15. Interpolated from the values of the scattering functions $\gamma_l(\tau)$, $\gamma_r(\tau)$ and $\bar{s}(\tau)$ computed by Z. Sekera et al.[8]. The values for the vertical optical thickness published by D. Deirmendjian [9] have furthermore been applied. h = solar altitude.

h \ λ	300	310	320	330	340	50	360	370	380	390	400
10°	0.01	0.02	0.04	0.06	0.09	0.13	0.18	0.25	0.31	0.40	0.48
15°	0.07	0.10	0.15	0.21	0.28	0.37	0.45	0.56	0.68	0.82	0.97
20°	0.16	0.22	0.30	0.39	0.50	0.62	0.75	0.90	1.07	1.27	1.46
25°	0.27	0.36	0.46	0.58	0.72	0.88	1.05	1.24	1.45	1.69	1.93
30°	0.38	0.50	0.63	0.77	0.94	1.14	1.34	1.57	1.82	2.10	2.38
35°	0.50	0.64	0.79	0.96	1.14	1.37	1.61	1.86	2.15	2.46	2.80
40°	0.61	0.77	0.94	1.13	1.34	1.59	1.86	2.14	2.46	2.81	3.17
45°	0.71	0.89	1.08	1.29	1.52	1.79	2.08	2.40	2.74	3.12	3.52
50°	0.81	1.00	1.21	1.44	1.69	1.97	2.29	2.63	3.00	3.41	3.83
55°	0.90	1.10	1.33	1.56	1.83	2.14	2.47	2.83	3.24	3.67	4.11
60°	0.98	1.19	1.43	1.68	1.96	2.29	2.64	3.01	3.44	3.89	4.36
65°	1.05	1.27	1.52	1.77	2.07	2.41	2.77	3.16	3.61	4.07	4.57
70°	1.10	1.33	1.59	1.86	2.16	2.51	2.88	3.28	3.74	4.22	4.73
80°	1.17	1.42	1.68	1.97	2.29	2.63	3.04	3.43	3.91	4.40	4.94
90°	1.20	1.44	1.72	2.00	2.32	2.68	3.09	3.49	3.97	4.47	5.01

for the wavelength intervals indicated and show a distinct increase of the ratio with increasing solar altitude. An analogous trend is found in general for all other months for hours not too early or too late in the day. The original values for the different wavelengths scatter however condiderably around the mean trend represented by the curves. This scatter amounts in the case of June to $\pm$ 0.18 for 300 mμ $\leq \lambda \leq$ 320 mμ and to between $\pm$ 0.07 and $\pm$ 0.10 for 360 mμ $\leq \lambda \leq$ 370 mμ. No plausible values of the ratio could be obtained in many cases for early and late hours corresponding to $h \leq 20°$. The curves shown in Fig. 7 are therefore limited to the period 6.00 $\leq t \leq$ 12.00.

The ratios obtained for λ = 380 mμ reach a maximum for h = 40° which trend does not comply with that found for the next shorter wavelengths nor with the theoretical results. No curves basing on the results found for 380 mμ are therefore included in the diagrams of Figs. 7 to 9. The ratio S_v/H increases quite generally with increasing wavelength as far as wavelengths of 330 mμ $\leq \lambda \leq$ 370 mμ outside the region of ozone absorption are concerned. The ratios for $\lambda \geq$ 330 mμ exceed furthermore in most cases the average values for 300 mμ $\leq \lambda \leq$ 320 mμ, which are influenced by atmospheric ozone. A different trend with wavelength is however found for the hours near noon during the period from July to September. This can be seen for example from the diagram in Fig. 8 which shows the ratios for August as a function of wavelength. These curves represent again mean values averaged over the wavelength intervals indicated by the horizontal lines. The inverse trend as shown below 330 mμ by the curves for $t > 10.00$ is due to the influence of atmospheric ozone. According to our results it occurs only for ozone amounts below 0.250 cm and for higher solar altitudes. Some exceptions found for very low solar altitudes cannot be taken as significative. The effect of ozone on the ratio S_v/H will be shortly discussed below.

The annual variation of the ratio S_v/H obtained for noon is represented in Fig. 9. Similarly to what has been stated for the diurnal variation these curves show an increase of S_v/H with solar altitude reaching a maximum in the summer months. The ratios for $\lambda \geqq 330$ mμ reach their annual maximum together with that of solar altitude in June. The mean value of the ratio for 300 mμ $\leqq \lambda \leqq$ 320 mμ exceeds that for 330 mμ $\leqq \lambda \leqq$ 340 mμ during the period from June to September and its annual maximum is shifted from June to August. The scatter understood in the same sense as explained for the curves in Fig. 7 amounts on the average over all months of the year to ± 0.20 for the wavelength interval 300 mμ $\leqq \lambda \leqq$ 320 mμ, whereas a scatter of ± 0.06 to 0.09 was found for $\lambda \geqq 330$ mμ.

The trend of the curve for 300 mμ $\leqq \lambda \leqq$ 320 mμ can be understood by considering the influence of the monthly variation of atmospheric ozone. It follows from formula (1) that the effect of ozone on the ratio S_v/H is determined by the difference (T_H-T_G) of the coefficients T_H and T_G for sky and global radiation respectively. A variation ΔX of the amount of atmospheric ozone changes S_v/H by a factor of num long $(T_H-T_G)\,\Delta X$. The values of (T_H-T_G) range for solar altitudes $h < 40°$ and wavelengths $\lambda \geqq 307.5$ mμ between -1.1 cm^{-1} and $+1.0$ cm^{-1} (see Tables 3 a-b, page 16). No large effect of ozone variations on S_v/H is therefore to be expected according to our results for this region of solar altitudes and wavelengths. Gradually increasing values of (T_H-T_G) are found on the other hand for higher solar elevations and shorter wavelengths.

The monthly means $\bar{\bar{X}}$ of atmospheric ozone decrease between June and August by 0.026 cm (see Table 1, page 11) while solar altitude decreases from 66.5° to 57.0° during this period. The difference (T_H-T_G) ranges between -1.5 cm^{-1} and -6.5 cm^{-1} for these high solar elevations and for the wavelength interval 320 mμ $\geqq \lambda \geqq$ 300 mμ. The decrease of the monthly amount of ozone from June to August causes an increase of S_v/H by factors of 1.07 to

1.48 depending on wavelength. The shift of the annual maximum for 300 mμ $\leq \lambda \leq$ 320 mμ to August can thus be explained by the fact that the latter increase is larger on the average over the wavelength interval considered than the decrease of S_v/H caused by the diminishing solar altitude.

The effect of atmospheric ozone on S_v/H is smaller for lower solar elevations and the influence of solar altitude prevails for the remaining months of the year. The annual minimum of S_v/H coincides therefore with that of solar altitude.

The climatological results for the ratio S_v/H shown in Figs. 7 to 9 confirm that in the ultraviolet region sky radiation makes a larger contribution to global radiation than in the visible. Up to a certain solar elevation which depends on wavelength the diffuse radiation exceeds the solar component. The critical value of solar altitude for which the sky- and solar component become equal amounts for June and for 360 mμ $\leq \lambda \leq$ 370 mμ to $\approx 28°$ and increases for 300 mμ $\leq \lambda \leq$ 320 mμ to $\approx 53°$, as can be interpolated from the curves in Fig.7. These solar altitudes correspond in June in the morning to the hours t = 7.10 and 9.40 respectively.

Examining furthermore the ratio S_v/H in the course of the year it can be stated from Fig. 9 that on the average over the interval 300 mμ $\leq \lambda \leq$ 320 mμ the noon values of the solar component surmount those for sky radiation only for the period from May to September. The corresponding period for the wavelength interval 360 mμ $\leq \lambda \leq$ 370 mμ is longer and extends from February till October. This preponderance of the diffuse radiation over the solar component applies thus particularly to the wavelength region below 320 mμ which is of special importance for photobiology. This well-known result must be taken into account when the effects of natural ultraviolet radiation are considered in radiation climatology.

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LIST OF TABLES

Table 5-16: Hourly values of the spectral intensity of ultraviolet sky radiation H and global radiation G (expressed in $Wcm^{-2}m\mu^{-1}$) for every month of the year.

<u>Abbreviations:</u>

LAT Local apparent time

5.65-10 stands for $5.65 \cdot 10^{-10}$

The indices + and - relate to sunrise and sunset respectively.

The values in brackets are discussed in the text on page

<u>Table 5</u>: <u>January</u>

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
7.30 16.30	H			5.65-10	1.53-9	2.95-9	5.78-9	1.37-8	2.30-8
8.00 16.00	H			1.17-9	3.70-9	9.55-9	2.12-8	5.85-8	1.22-7
8.30 15.30	H			2.16-9	8.30-9	2.65-8	6.30-8	1.95-7	4.05-7
15.15$^-$	G			1.54-9	5.00-9	4.68-8	7.95-8	4.80-7	5.75-7
9.00	H			3.85-9	1.78-8	6.20-8	1.54-7	4.70-7	9.25-7
15.00	G			(2.26-9	9.60-9)	6.65-8	(1.38-7)	6.38-7	(8.90-7)
9.30$^+$	H		1.08-9	6.50-9	3.43-8	1.25-7	3.08-7	8.55-7	1.62-6
14.30	G			(4.57-9	2.76-8)	1.27-7	3.13-7	1.06-6	1.72-6
10.00	H		1.66-9	1.02-8	5.90-8	2.05-7	5.03-7	1.30-6	2.37-6
14.00	G		(1.16-9	8.15-9	5.90-8)	2.12-7	5.47-7	1.57-6	2.68-6
10.30	H		2.40-9	1.46-8	8.80-8	2.90-7	7.10-7	1.73-6	3.02-6
13.30	G		(1.97-9	1.28-8)	9.98-8	3.12-7	8.15-7	2.07-6	3.63-6
11.00	H		3.08-9	1.91-8	1.18-7	3.70-7	8.80-7	2.09-6	3.55-6
13.00	G		(2.81-9	1.81-8)	1.38-7	4.13-7	1.04-6	2.53-6	4.42-6
12.00	H		3.78-9	2.35-8	1.46-7	4.45-7	1.02-6	2.40-6	3.95-6
12.00	G		(3.72-9	2.34-8)	1.77-7	5.05-7	1.25-6	2.93-6	5.08-6

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
4.62-8	6.65-8	1.72-7	3.85-7	4.60-7	5.30-7	5.40-7	5.70-7	5.10-7
2.44-7	4.05-7	8.90-7	1.78-6	2.37-6	2.55-6	2.65-6	3.03-6	2.86-6
7.95-7	1.22-6	2.54-6	4.60-6	5.20-6	5.30-6	5.42-6	6.35-6	6.03-6
1.43-6	2.04-6	3.90-6	6.35-6	7.00-6	7.20-6	7.25-6	9.00-6	8.19-6
1.69-6	2.56-6	4.62-6	7.25-6	8.00-6	8.00-6	7.95-6	9.30-6	8.53-6
1.89-6	2.77-6	5.05-6	7.80-6	8.70-6	9.35-6	9.20-6	1.17-5	1.08-5
2.80-6	4.10-6	6.70-6	9.80-6	1.04-5	1.04-5	1.00-5	1.14-5	1.00-5
3.03-6	4.48-6	7.55-6	1.11-5	1.26-5	1.32-5	1.31-5	1.65-5	1.53-5
3.85-6	5.50-6	8.45-6	1.19-5	1.24-5	1.24-5	1.17-5	1.32-5	1.14-5
4.30-6	6.25-6	1.01-5	1.44-5	1.63-5	1.65-5	1.68-5	2.06-5	1.92-5
4.77-6	6.57-6	9.80-6	1.38-5	1.40-5	1.38-5	1.31-5	1.44-5	1.23-5
5.55-6	7.98-6	1.26-5	1.74-5	1.95-5	1.96-5	2.03-5	2.42-5	2.25-5
5.50-6	7.30-6	1.08-5	1.50-5	1.52-5	1.48-5	1.42-5	1.54-5	1.30-5
6.60-6	9.37-6	1.43-5	1.98-5	2.22-5	2.21-5	2.30-5	2.72-5	2.53-5
6.05-6	7.90-6	1.16-5	1.60-5	1.61-5	1.57-5	1.48-5	1.62-5	1.37-5
7.55-6	1.04-5	1.57-5	2.17-5	2.42-5	2.42-5	2.52-5	2.95-5	2.77-5

Table 6: February

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
7.00 17.00	H			5.35-10	1.57-9	3.62-9	7.80-9	2.08-8	3.95-8
7.30 16.30	H		1.47-10	1.14-9	4.15-9	1.23-8	2.95-8	9.15-8	2.09-7
8.00 16.00	H		3.28-10	2.38-9	1.02-8	3.55-8	9.30-8	3.05-7	6.50-7
8.30	H		6.75-10	4.62-9	2.26-8	8.62-8	2.22-7	7.00-7	1.38-6
15.30⁻	G			(2.92-9	1.97-8)	9.15-8	2.27-7	8.60-7	1.56-6
8.45⁺	G		6.40-10	4.45-9	3.25-8	1.34-7	3.53-7	1.18-6	2.14-6
9.00	H		1.35-9	8.70-9	4.80-8	1.82-7	4.42-7	1.29-6	2.42-6
15.00	G		(1.00-9	6.80-9)	5.30-8	1.92-7	5.25-7	1.58-6	2.87-6
9.30	H		2.43-9	1.53-8	9.05-8	3.18-7	7.40-7	2.00-6	3.50-6
14.30	G		(2.22-9	1.38-8)	1.14-7	3.53-7	9.45-7	2.44-6	4.41-6
10.00	H		3.98-9	2.47-8	1.48-7	4.82-7	1.08-6	2.75-6	4.45-6
14.00	G	7.38-10	4.15-9	2.48-8	1.98-7	5.65-7	1.42-6	3.37-6	5.95-6
10.30	H		5.95-9	3.63-8	2.17-7	6.50-7	1.38-6	3.40-6	5.25-6
13.30	G	1.13-9	6.82-9	3.95-8	2.91-7	7.95-7	1.88-6	4.28-6	7.30-6
11.00	H	2.00-9	8.00-9	4.83-8	2.80-7	7.95-7	1.62-6	3.92-6	5.75-6
13.00	G	(1.55-9)	9.75-9	5.50-8	3.77-7	1.01-6	2.25-6	5.02-6	8.35-6
12.00	H	2.30-9	1.02-8	6.00-8	3.33-7	9.30-7	1.80-6	4.37-6	6.20-6
12.00	G	(2.00-9)	1.30-8	7.20-8	4.55-7	1.22-6	2.58-6	5.70-6	9.20-6

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
8.20-8	1.26-7	3.30-7	7.05-7	1.02-6	1.14-6	1.21-6	1.25-6	1.14-6
4.16-7	6.75-7	1.46-6	2.95-6	3.78-6	3.90-6	4.03-6	4.68-6	4.51-6
1.23-6	1.93-6	3.74-6	6.22-6	7.20-6	7.25-6	7.30-6	8.50-6	7.91-6
2.45-6	3.68-6	6.25-6	9.50-6	1.04-5	1.04-5	1.00-5	1.13-5	9.93-6
2.73-6	4.18-6	7.12-6	1.10-5	1.25-5	1.32-5	1.29-5	1.65-5	1.53-5
3.58-6	5.30-6	8.80-6	1.34-5	1.52-5	1.54-5	1.58-5	1.94-5	1.80-5
3.98-6	5.50-6	8.70-6	1.25-5	1.33-5	1.32-5	1.25-5	1.38-5	1.17-5
4.51-6	6.63-6	1.08-5	1.62-5	1.81-5	1.82-5	1.87-5	2.25-5	2.09-5
5.45-6	7.15-6	1.08-5	1.52-5	1.58-5	1.54-5	1.46-5	1.58-5	1.33-5
6.60-6	9.30-6	1.45-5	2.10-5	2.35-5	2.33-5	2.43-5	2.85-5	2.65-5
6.75-6	8.45-6	1.24-5	1.74-5	1.78-5	1.71-5	1.63-5	1.74-5	1.46-5
8.65-6	1.18-5	1.78-5	2.53-5	2.80-5	2.82-5	2.93-5	3.37-5	3.17-5
7.80-6	9.45-6	1.37-5	1.90-5	1.94-5	1.84-5	1.76-5	1.86-5	1.56-5
1.05-5	1.40-5	2.04-5	2.88-5	3.17-5	3.21-5	3.33-5	3.78-5	3.59-5
8.60-6	1.02-5	1.46-5	2.02-5	2.05-5	1.93-5	1.84-5	1.95-5	1.63-5
1.19-5	1.57-5	2.23-5	3.12-5	3.42-5	3.50-5	3.60-5	4.07-5	3.87-5
9.22-6	1.08-5	1.53-5	2.12-5	2.14-5	2.00-5	1.90-5	2.01-5	1.69-5
1.32-5	1.70-5	2.40-5	3.32-5	3.58-5	3.73-5	3.80-5	4.28-5	4.11-5

Table 7: March

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
6.00	H				9.65-10	1.85-9	3.90-9	1.00-8	1.67-8
18.00									
6.30	H		1.07-10	7.00-10	2.67-9	7.30-9	1.77-8	5.15-8	1.18-7
17.30									
7.00	H		2.46-10	1.60-9	6.80-9	2.37-8	6.25-8	2.05-7	4.73-7
17.00									
7.30	H		5.45-10	3.55-9	1.74-8	6.85-8	1.75-7	5.70-7	1.19-6
16.30									
7.50+	G		5.70-10	4.05-9	3.10-8	1.22-7	3.55-7	1.20-6	2.20-6
16.10-	G								
8.00	H		1.20-9	7.75-9	4.35-8	1.72-7	4.10-7	1.25-6	2.32-6
16.00	G		(8.65-10	5.85-9)	4.85-8	(1.72-7)	5.00-7	1.54-6	2.85-6
8.30	H		2.55-9	1.63-8	1.00-7	3.50-7	8.10-7	2.18-6	3.68-6
15.30	G		(2.39-9	1.50-8)	1.25-7	3.92-7	1.04-6	2.68-6	4.92-6
9.00	H		5.10-9	3.20-8	1.96-7	6.05-7	1.29-6	3.22-6	5.05-6
15.00	G		5.65-9	3.48-8	2.52-7	7.30-7	1.76-6	4.15-6	7.18-6
9.30	H	2.11-9	9.70-9	5.80-8	3.18-7	9.25-7	1.77-6	4.32-6	6.25-6
14.30	G	(1.84-9)	1.22-8	7.00-8	4.35-7	1.18-6	2.57-6	5.80-6	9.30-6
10.00	H	2.92-9	1.70-8	9.15-8	4.48-7	1.26-6	2.18-6	5.30-6	7.20-6
14.00	G	3.22-9	2.25-8	1.19-7	6.55-7	1.67-6	3.37-6	7.30-6	1.12-5
10.30	H	3.80-9	2.63-8	1.28-7	5.70-7	1.57-6	2.52-6	6.10-6	8.05-6
13.30	G	5.05-9	3.60-8	1.76-7	8.65-7	2.15-6	4.05-6	8.65-6	1.28-5
11.00	H	4.68-9	3.45-8	1.60-7	6.60-7	1.82-6	2.78-6	6.65-6	8.70-6
13.00	G	6.95-9	4.90-8	2.29-7	1.04-6	2.57-6	4.60-6	9.75-6	1.41-5
12.00	H	5.55-9	4.15-8	1.89-7	7.45-7	2.03-6	3.00-6	7.10-6	9.20-6
12.00	G	9.00-9	6.20-8	2.84-7	1.21-6	2.93-6	5.10-6	1.07-5	1.51-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
3.42-8	5.12-8	1.46-7	3.00-7	3.50-7	4.10-7	4.30-7	4.45-7	3.98-7
2.33-7	3.95-7	1.00-6	1.98-6	2.63-6	2.78-6	2.93-6	3.35-6	3.20-6
8.90-7	1.42-6	3.25-6	5.30-6	6.40-6	6.40-6	6.50-6	7.60-6	7.15-6
2.15-6	3.26-6	6.30-6	9.05-6	1.01-5	1.01-5	9.70-6	1.12-5	9.86-6
3.65-6	5.40-6	9.20-6	1.40-5	1.62-5	1.64-5	1.67-5	2.04-5	1.91-5
3.95-6	5.48-6	9.15-6	1.28-5	1.35-5	1.34-5	1.27-5	1.41-5	1.20-5
4.52-6	6.55-6	1.08-5	1.63-5	1.87-5	1.87-5	1.93-5	2.32-5	2.16-5
5.88-6	7.50-6	1.19-5	1.62-5	1.68-5	1.63-5	1.55-5	1.67-5	1.41-5
7.40-6	1.02-5	1.58-5	2.28-5	2.58-5	2.58-5	2.68-5	3.10-5	2.92-5
7.65-6	9.35-6	1.44-5	1.92-5	1.95-5	1.85-5	1.76-5	1.88-5	1.58-5
1.04-5	1.39-5	2.06-5	2.89-5	3.20-5	3.26-5	3.37-5	3.80-5	3.61-5
9.25-6	1.08-5	1.63-5	2.15-5	2.19-5	2.03-5	1.95-5	2.06-5	1.73-5
1.35-5	1.76-5	2.47-5	3.45-5	3.74-5	3.84-5	3.90-5	4.42-5	4.24-5
1.07-5	1.22-5	1.78-5	2.34-5	2.38-5	2.18-5	2.09-5	2.18-5	1.84-5
1.64-5	2.05-5	2.80-5	3.93-5	4.19-5	4.32-5	4.35-5	4.98-5	4.81-5
1.18-5	1.33-5	1.88-5	2.47-5	2.52-5	2.30-5	2.20-5	2.28-5	1.94-5
1.87-5	2.28-5	3.06-5	4.33-5	4.57-5	4.70-5	4.72-5	5.42-5	5.26-5
1.26-5	1.42-5	1.95-5	2.55-5	2.61-5	2.39-5	2.28-5	2.34-5	2.00-5
2.04-5	2.43-5	3.23-5	4.60-5	4.82-5	5.00-5	5.00-5	5.78-5	5.61-5
1.32-5	1.48-5	2.02-5	2.63-5	2.68-5	2.47-5	2.35-5	2.39-5	2.07-5
2.20-5	2.58-5	3.39-5	4.85-5	5.08-5	5.25-5	5.22-5	6.05-5	5.87-5

Table 8: April

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
5.00 19.00	H			2.57-10	7.70-10	1.33-9	2.53-9	6 30-9	9 90-9
5.30 18.30	H			5.65-10	1.98-9	4.90-9	1.12-8	3.10-8	6.75-8
6.00+	H			1.27-9	5.15-9	1.64-8	4.25-8	1.36-7	3.20-7
18.00	G			(5.15-10	2.40-9)	1.76-8	(3.52-8)	2.05-7	4.05-7
6.30	H		3.90-10	2.85-9	1.37-8	4.95-8	1.34-7	4.40-7	9.45-7
17.30	G			(1.57-9	9.90-9)	5.05-8	(1.22-7)	5.70-7	1.04-6
7.00	H		9.60-10	6.55-9	3.58-8	1.38-7	3.53-7	1.07-6	2.08-6
17.00−	G		(6.90-10	4.70-9)	3.73-8	(1.38-7)	4.10-7	1.29-6	2.46-6
7.30	H		2.32-9	1.46-8	9.10-8	3.18-7	7.70-7	2.04-6	3.65-6
16.30	G		(2.07-9	1.34-8)	1.13-7	3.48-7	9.65-7	2.50-6	4.60-6
8.00	H		5.45-9	3.22-8	1.98-7	6.20-7	1.33-6	3.30-6	5.20-6
16.00	G		5.80-9	3.55-8	2.66-7	7.50-7	1.82-6	4.25-6	7.30-6
8.30	H	2.22-9	1.20-8	6.55-8	3.58-7	1.01-6	1.91-6	4.65-6	6.62-6
15.30	G	(2.15-9)	1.44-8	8.05-8	5.05-7	1.38-6	2.82-6	6.28-6	9.95-6
9.00	H	3.52-9	2.42-8	1.18-7	5.50-7	1.50-6	2.50-6	5.95-6	8.05-6
15.00	G	4.35-9	3.23-8	1.58-7	8.20-7	2.14-6	3.92-6	8.50-6	1.27-5
9.30	H	5.50-9	4.13-8	1.86-7	7.65-7	2.00-6	3.10-6	7.02-6	9.50-6
14.30	G	8.20-9	6.10-8	2.70-7	1.18-6	2.96-6	5.04-6	1.08-5	1.52-5
10.00	H	7.95-9	5.75-8	2.53-7	9.55-7	2.44-6	3.62-6	7.95-6	1.07-5
14.00	G	1.40-8	9.30-8	4.02-7	1.58-6	3.80-6	6.05-6	1.32-5	1.77-5
10.30	H	1.08-8	7.35-8	3.17-7	1.13-6	2.78-6	4.05-6	8.60-6	1.15-5
13.30	G	2.15-8	1.25-7	5.37-7	1.97-6	4.57-6	7.00-6	1.52-5	1.99-5
11.00	H	1.37-8	8.55-8	3.62-7	1.25-6	3.02-6	4.35-6	9.00-6	1.22-5
13.00	G	2.92-8	1.48-7	6.50-7	2.28-6	5.10-6	7.70-6	1.66-5	2.16-5
12.00	H	1.68-8	9.75-8	4.02-7	1.37-6	3.20-6	4.60-6	9.40-6	1.28-5
12.00	G	3.75-8	1.70-7	7.65-7	2.58-6	5.58-6	8.40-6	1.80-5	2.32-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
2.13-8	2.70-8	7.35-8	1.28-7	1.25-7	1.50-7	1.53-7	1.65-7	1.46-7
1.38-7	2.30-7	5.55-7	1.21-6	1.72-6	1.88-6	1.98-6	2.20-6	2.05-6
6.30-7	1.00-6	2.18-6	4.23-6	5.15-6	5.25-6	5.38-6	6.25-6	5.94-6
8.65-7	1.47-6	2.81-6	4.68-6	5.32-6	5.50-6	5.60-6	6.50-6	(5.85-6)
1.78-6	2.68-6	4.95-6	8.05-6	9.05-6	9.00-6	8.85-6	1.02-5	9.18-6
1.98-6	3.12-6	5.55-6	8.80-6	1.03-5	1.09-5	1.08-5	1.37-5	1.26-5
3.62-6	4.95-6	8.10-6	1.21-5	1.28-5	1.28-5	1.22-5	1.35-5	1.16-5
4.00-6	5.95-6	1.00-5	1.52-5	1.72-5	1.73-5	1.77-5	2.15-5	2.00-5
5.62-6	7.30-6	1.11-5	1.58-5	1.64-5	1.60-5	1.52-5	1.64-5	1.38-5
7.00-6	9.60-6	1.52-5	2.22-5	2.49-5	2.50-5	2.60-5	3.01-5	2.83-5
7.65-6	9.45-6	1.38-5	1.93-5	1.97-5	1.87-5	1.78-5	1.88-5	1.58-5
1.07-5	1.41-5	2.07-5	2.96-5	3.24-5	3.31-5	3.42-5	3.85-5	3.66-5
9.65-6	1.15-5	1.61-5	2.20-5	2.25-5	2.09-5	2.00-5	2.10-5	1.77-5
1.45-5	1.83-5	2.53-5	3.60-5	3.83-5	4.01-5	4.08-5	4.60-5	4.42-5
1.14-5	1.32-5	1.81-5	2.43-5	2.50-5	2.28-5	2.19-5	2.27-5	1.93-5
1.83.5	2.23-5	3.00-5	4.27-5	4.50-5	4.65-5	4.68-5	5.35-5	5.19-5
1.31-5	1.48-5	2.00-5	2.63-5	2.69-5	2.47-5	2.37-5	2.38-5	2.05-5
2.18-5	2.56-5	3.38-5	4.90-5	5.08-5	5.25-5	5.25-5	6.08-5	5.90-5
1.43-5	1.63-5	2.16-5	2.82-5	2.84-5	2.63-5	2.50-5	2.50-5	2.19-5
2.49-5	2.87-5	3.72-5	5.45-5	5.60-5	5.80-5	5.72-5	6.60-5	6.34-5
1.50-5	1.76-5	2.28-5	2.95-5	2.97-5	2.75-5	2.62-5	2.57-5	2.29-5
2.78-5	3.13-5	4.00-5	5.90-5	6.03-5	6.25-5	6.18-5	7.00-5	6.65-5
1.58-5	1.85-5	2.40-5	3.07-5	3.07-5	2.84-5	2.70-5	2.62-5	2.36-5
2.98-5	3.33-5	4.22-5	6.25-5	6.32-5	6.57-5	6.50-5	7.22-5	6.79-5
1.62-5	1.91-5	2.48-5	3.15-5	3.13-5	2.92-5	2.78-5	2.68-5	2.46-5
3.15-5	3.50-5	4.40-5	6.55-5	6.55-5	6.83-5	6.78-5	7.40-5	6.88-5

Table 9: May

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
4.30 19.30	H				4.68-10	1.45-9	2.68-9	8.05-9	1.33-8
5.00 19.00	H			3.43-10	1.30-9	4.33-9	9.50-9	3.25-8	7.75-8
5.15$^+$	G			4.65-10	2.92-9	1.00-8	3.50-8	1.33-7	4.75-7
5.30	H		1.05-10	8.15-10	3.63-9	1.28-8	3.18-8	1.21-7	2.93-7
18.30	G			(7.25-10)	4.73-9	1.65-8	5.40-8	1.98-7	6.30-7
6.00	H		3.20-10	2.02-9	1.03-8	3.82-8	1.01-7	3.60-7	8.05-7
18.00	G			(1.83-9)	1.32-8	4.35-8	1.30-7	4.55-7	1.13-6
17.45$^-$	G			3.05-9	2.14-8	7.30-8	1.97-7	6.90-7	1.49-6
6.30	H		9.35-10	4.95-9	2.82-8	1.08-7	2.70-7	8.40-7	1.73-6
17.30	G		(8.05-10	4.82-9)	3.52-8	1.14-7	3.00-7	1.00-6	1.97-6
7.00	H		2.60-9	1.25-8	7.50-8	2.55-7	6.10-7	1.56-6	2.87-6
17.00	G		(2.28-9)	1.28-8	9.00-8	2.75-7	6.55-7	2.00-6	3.37-6
7.30	H	1.25-9	6.80-9	3.20-8	1.76-7	5.20-7	1.07-6	2.51-6	4.00-6
16.30	G	(8.65-10	6.20-9)	3.40-8	2.13-7	6.00-7	1.32-6	3.60-6	5.55-6
8.00	H	2.40-9	1.61-8	7.75-8	3.46-7	8.98-7	1.59-6	3.58-6	5.20-6
16.00	G	(2.38-9	1.63-8)	8.65-8	4.45-7	1.18-6	2.31-6	5.65-6	8.40-6
8.30	H	4.48-9	3.17-8	1.54-7	5.70-7	1.35-6	2.16-6	4.60-6	6.35-6
15.30	G	5.50-9	3.73-8	1.82-7	8.00-7	2.05-6	3.50-6	7.90-6	1.13-5
9.00	H	8.08-9	5.30-8	2.45-7	8.25-7	1.82-6	2.75-6	5.50-6	7.35-6
15.00	G	1.02-8	7.25-8	3.10-7	1.25-6	3.07-6	4.73-6	1.01-5	1.39-5
9.30	H	1.35-8	7.70-8	3.21-7	1.07-6	2.20-6	3.33-6	6.25-6	8.20-6
14.30	G	1.71-8	1.20-7	4.45-7	1.74-6	3.87-6	5.90-6	1.18-5	1.62-5
10.00	H	2.05-8	1.01-7	3.87-7	1.27-6	2.48-6	3.83-6	6.85-6	8.85-6
14.00	G	2.65-8	1.73-7	5.75-7	2.18-6	4.45-6	6.87-6	1.33-5	1.77-5
10.30	H	2.75-8	1.21-7	4.38-7	1.42-6	2.67-6	4.24-6	7.23-6	9.53-6
13.30	G	3.71-8	2.27-7	6.95-7	2.60-6	4.89-6	7.75-6	1.42-5	1.88-5
11.00	H	3.27-8	1.35-7	4.77-7	1.53-6	2.78-6	4.55-6	7.50-6	9.70-6
13.00	G	4.63-8	2.75-7	7.95-7	2.92-6	5.18-6	8.45-6	1.49-5	1.97-5
12.00	H	3.77-8	1.46-7	5.10-7	1.61-6	2.88-6	4.83-6	7.70-6	1.00-5
12.00	G	5.50-8	3.21-7	8.85-7	3.20-6	5.38-6	9.05-6	1.55-5	2.03-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
2.50-8	3.75-8	1.02-7	2.17-7	3.70-7	4.80-7	4.90-7	5.60-7	5.03-7
1.57-7	2.69-7	6.70-7	1.42-6	1.87-6	2.38-6	2.48-6	2.82-6	2.69-6
8.40-7	1.41-6	2.82-6	3.78-6	4.95-6	6.30-6	6.70-6	9.70-6	8.64-6
6.10-7	9.10-7	1.94-6	3.80-6	4.50-6	5.35-6	5.53-6	6.15-6	5.15-6
1.09-6	1.76-6	3.40-6	4.72-6	6.05-6	7.45-6	8.00-6	1.13-5	1.03-5
1.44-6	2.05-6	3.83-6	6.75-6	7.65-6	8.20-6	8.40-6	9.25-6	8.17-6
1.87-6	2.75-6	5.00-6	7.60-6	9.15-6	1.07-5	1.13-5	1.54-5	1.43-5
2.50-6	3.44-6	6.00-6	9.50-6	1.11-5	1.26-5	1.35-5	1.81-5	1.68-5
2.54-6	3.68-6	5.95-6	9.65-6	1.03-5	1.08-5	1.07-5	1.19-5	1.01-5
3.12-6	4.25-6	7.20-6	1.19-5	1.35-5	1.50-5	1.58-5	2.08-5	1.93-5
3.95-6	5.60-6	8.00-6	1.21-5	1.30-5	1.32-5	1.27-5	1.44-5	1.21-5
5.10-6	6.50-6	1.03-5	1.76-5	1.89-5	2.05-5	2.15-5	2.75-5	2.58-5
5.45-6	7.55-6	1.00-5	1.43-5	1.51-5	1.52-5	1.45-5	1.66-5	1.39-5
7.85-6	9.75-6	1.45-5	2.36-5	2.50-5	2.72-5	2.80-5	3.47-5	3.30-5
7.00-6	9.25-6	1.19-5	1.62-5	1.68-5	1.68-5	1.60-5	1.85-5	1.56-5
1.14-5	1.42-5	1.98-5	2.94-5	3.09-5	3.38-5	3.50-5	4.25-5	4.03-5
8.43-6	1.08-5	1.37-5	1.78-5	1.82-5	1.83-5	1.72-5	1.98-5	1.69-5
1.53-5	1.85-5	2.55-5	3.43-5	3.61-5	3.93-5	4.08-5	4.93-5	4.78-5
9.75-6	1.19-5	1.52-5	1.91-5	1.92-5	1.94-5	1.81-5	2.09-5	1.82-5
1.95-5	2.22-5	3.06-5	3.87-5	4.08-5	4.42-5	4.55-5	5.45-5	5.29-5
1.08-5	1.28-5	1.67-5	2.00-5	1.99-5	2.00-5	1.88-5	2.17-5	1.93-5
2.37-5	2.53-5	3.50-5	4.28-5	4.50-5	4.80-5	4.90-5	5.80-5	5.51-5
1.16-5	1.37-5	1.78-5	2.09-5	2.05-5	2.04-5	1.95-5	2.23-5	2.03-5
2.70-5	2.77-5	3.81-5	4.60-5	4.85-5	5.05-5	5.20-5	6.10-5	5.67-5
1.22-5	1.43-5	1.89-5	2.16-5	2.10-5	2.07-5	2.01-5	2.28-5	2.13-5
2.90-5	2.95-5	4.05-5	4.90-5	5.13-5	5.22-5	5.45-5	6.35-5	5.84-5
1.27-5	1.47-5	1.97-5	2.19-5	2.12-5	2.08-5	2.04-5	2.31-5	2.19-5
3.07-5	3.09-5	4.25-5	5.12-5	5.35-5	5.35-5	5.60-5	6.50-5	5.92-5
1.29-5	1.50-5	2.03-5	2.22-5	2.17-5	2.10-5	2.07-5	2.33-5	2.24-5
3.18-5	3.21-5	4.40-5	5.35-5	5.55-5	5.40-5	5.75-5	6.65-5	5.99-5

Table 10: June

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
4.00	H				4.58-10	9.40-10	1.87-9	5.00-9	8.70-9
20.00									
4.30	H			3.65-10	1.20-9	4.04-9	9.20-9	2.50-8	5.10-8
19.30									
5.00+	H			8.20-10	3.18-9	1.22-8	2.77-8	9.80-8	2.00-7
19.00	G			(7.10-10)	4.80-9	1.55-8	5.00-8	1.40-7	5.65-7
5.30	H		3.17.10	1.88-9	8.70-9	3.18-8	8.00-8	2.88-7	6.25-7
18.30	G			(1.83-9)	1.24-8	4.10-8	1.18-7	3.75-7	9.75-7
6.00	H		8.35-10	4.50-9	2.38-8	8.50-8	2.25-7	7.00-7	1.42-6
18.00	G		(7.57-10)	4.65-9	3.15-8	1.04-7	2.67-7	8.50-7	1.68-6
6.30	H		2.28-9	1.11-8	6.40-8	2.18-7	5.25-7	1.41-6	2.57-6
17.30	G		(2.05-9)	1.18-8	8.00-8	2.43-7	5.70-7	1.70-6	2.87-6
7.00	H		6.20-9	2.78-8	1.57-7	4.77-7	9.80-7	2.31-6	3.77-6
17.00	G		(5.55-9)	3.10-8	1.87-7	5.10-7	1.12-6	3.08-6	4.73-6
7.30	H	2.18-9	1.48-8	6.95-8	3.11-7	8.40-7	1.52-6	3.33-6	5.00-6
16.30	G	(2.07-9	1.47-8)	7.90-8	3.97-7	1.01-6	2.02-6	5.00-6	7.30-6
8.00	H	4.25-9	3.00-8	1.57-7	5.35-7	1.30-6	2.08-6	4.40-6	6.10-6
16.00	G	5.25-9	3.70-8	1.76-7	7.50-7	1.88-6	3.30-6	7.40-6	1.03-5
8.30	H	8.00-9	5.35-8	2.54-7	8.35-7	1.79-6	2.70-6	5.50-6	7.20-6
15.30	G	1.19-8	7.85-8	3.32-7	1.28-6	3.10-6	4.78-6	1.00-5	1.36-5
9.00	H	1.45-8	8.40-8	3.43-7	1.11-6	2.28-6	3.32-6	6.40-6	8.15-6
15.00	G	2.28-8	1.39-7	5.20-7	1.91-6	4.32-6	6.33-6	1.24-5	1.62-5
9.30	H	2.42-8	1.14-7	4.25-7	1.34-6	2.65-6	3.98-6	7.02-6	8.95-6
14.30	G	3.87-8	2.20-7	7.20-7	2.58-6	5.25-6	7.70-6	1.42-5	1.84-5
10.00	H	3.48-8	1.41-7	4.95-7	1.53-6	2.91-6	4.48-6	7.54-6	9.55-6
14.00	G	5.78-8	3.16-7	9.10-7	3.26-6	5.88-6	8.90-6	1.56-5	2.02-5
10.30	H	4.47-8	1.64-7	5.55-7	1.67-6	3.10-6	4.90-6	7.90-6	1.01-5
13.30	G	7.80-8	4.15-7	1.10-6	3.82-6	6.30-6	1.00-5	1.68-5	2.15-5
11.00	H	5.25-8	1.78-7	6.05-7	1.80-6	3.20-6	5.28-6	8.15-6	1.04-5
13.00	G	9.50-8	5.00-7	1.27-6	4.23-6	6.58-6	1.08-5	1.76-5	2.24-5
12.00	H	5.95-8	1.90-7	6.45-7	1.90-6	3.30-6	5.50-6	8.40-6	1.07-5
12.00	G	1.10-7	5.75-7	1.42-6	4.56-6	6.78-6	1.17-5	1.83-5	2.32-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
1.52-8	2.35-8	o.45-8	I.05-7	1.60-7	2.25-7	2.63-7	3.15-7	2.80-7
1.03-7	1.73-7	4.70-7	1.00-6	1.30-6	1.62-6	1.70-6	1.95-6	1.82-6
4.55-7	7.00-7	1.52-6	2.97-6	3.42-6	4.22-6	4.38-6	4.90-6	4.66-6
9.30-7	1.63-6	3.10-6	3.80-6	5.40-6	6.61-6	7.20-6	1.00-5	9.00-6
1.21-6	1.68-6	3.18-6	5.55-6	6.35-6	7.05-6	7.25-6	8.00-6	7.26-6
1.63-6	2.50-6	4.55-6	6.18-6	7.70-6	9.30-6	9.95-6	1.37-5	1.26-5
2.27-6	3.19-6	5.22-6	8.60-6	9.20-6	9.60-6	9.65-6	1.07-5	9.25-6
2.77-6	3.74-6	6.40-6	9.75-6	1.14-5	1.30-5	1.38-5	1.84-5	1.71-5
3.58-6	5.05-6	7.50-6	1.13-5	1.18-5	1.21-5	1.18-5	1.33-5	1.12-5
4.50-6	5.60-6	8.98-6	1.50-5	1.64-5	1.90-5	1.89-5	2.45-5	2.29-5
5.05-6	7.10-6	9.50-6	1.35-5	1.42-5	1.42-5	1.37-5	1.56-5	1.31-5
6.87-6	8.45-6	1.27-5	2.13-5	2.23-5	2.42-5	2.50-5	3.15-5	2.99-5
6.65-6	9.00-6	1.13-5	1.54-5	1.59-5	1.59-5	1.53-5	1.76-5	1.48-5
1.01-5	1.25-5	1.76-5	2.69-5	2.83-5	2.98-5	3.20-5	3.90-5	3.74-5
8.15-6	1.06-5	1.31-5	1.70-5	1.76-5	1.76-5	1.66-5	1.92-5	1.63-5
1.40-5	1.72-5	2.34-5	3.19-5	3.38-5	3.72-5	3.84-5	4.67-5	4.53-5
9.50-6	1.18-5	1.48-5	1.85-5	1.87-5	1.89-5	1.76-5	2.03-5	1.76-5
1.84-5	2.18-5	2.95-5	3.67-5	3.90-5	4.25-5	4.37-5	5.25-5	5.09-5
1.08-5	1.29-5	1.64-5	1.97-5	1.96-5	1.97-5	1.85-5	2.13-5	1.89-5
2.22-5	2.53-5	3.47-5	4.12-5	4.35-5	4.70-5	4.78-5	5.68-5	5.42-5
1.18-5	1.39-5	1.77-5	2.07-5	2.02-5	2.02-5	1.93-5	2.22-5	2.01-5
2.51-5	2.84-5	3.88-5	4.53-5	4.75-5	5.01-5	5.15-5	6.03-5	5.67-5
1.27-5	1.46-5	1.90-5	2.15-5	2.08-5	2.06-5	1.98-5	2.28-5	2.11-5
2.75-5	3.10-5	4.22-5	4.92-5	5.10-5	5.22-5	5.42-5	6.30-5	5.80-5
1.32-5	1.51-5	2.01-5	2.20-5	2.13-5	2.08-5	2.03-5	2.32-5	2.20-5
2.95-5	3.30-5	4.52-5	5.22-5	5.40-5	5.41-5	5.65-5	6.55-5	5.89-5
1.35-5	1.53-5	2.09-5	2.24-5	2.18-5	2.10-5	2.07-5	2.34-5	2.27-5
3.10-5	3.50-5	4.73-5	5.48-5	5.60-5	5.45-5	5.81-5	6.70-5	2.27-5
1.37-5	1.56-5	2.15-5	2.27-5	2.22-5	2.13-5	2.10-5	2.36-5	2.30-5
3.23-5	3.57-5	4.90-5	5.72-5	5.82-5	5.70-5	6.00-5	6.85-5	6.30-5

Table 11: July

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
4.00 20.00	H				3.28-10	1.02-9	1.59-9	3.70-9	5.70-9
4.30 19.30	H			3.62-10	1.26-9	3.38-9	6.75-9	1.80-8	3.53-8
5.00+ 19.00	H G			8.70-10 9.30-10	3.82-9 4.90-9	1.14-8 2.28-8	2.57-8 6.55-8	8.15-8 2.02-7	1.70-7 5.58-7
5.30 18.30	H G		3.95-10	2.18-9 2.25-9	1.09-8 1.33-8	3.45-8 5.00-8	8.40-8 1.35-7	2.90-7 4.10-7	5.60-7 9.45-7
6.00 18.00-	H G		9.90-10 (9.50-10)	5.40-9 5.50-9	2.80-8 3.55-8	9.55-8 1.14-7	2.37-7 2.85-7	7.15-7 8.40-7	1.37-6 1.62-6
6.30 17.30	H G		2.55-9 (2.50-9)	1.25-8 1.40-8	7.20-8 9.10-8	2.38-7 2.57-7	5.50-7 5.83-7	1.38-6 1.64-6	2.52-6 2.75-6
7.00 17.00	H G		6.65-9 (6.60-9)	3.28-8 3.58-8	1.68-7 2.15-7	4.90-7 5.50-7	1.03-6 1.15-6	2.27-6 2.90-6	3.80-6 4.52-6
7.30 16.30	H G	2.55-9 (2.43-9)	1.61-8 1.76-8	7.60-8 8.90-8	3.38-7 4.40-7	8.80-7 1.11-6	1.62-6 2.07-6	3.30-6 4.82-6	5.00-6 7.05-6
8.00 16.00	H G	4.95-9 5.90-9	3.33-8 4.30-8	1.57-7 1.99-7	5.85-7 8.15-7	1.38-6 2.01-6	2.19-6 3.38-6	4.38-6 7.35-6	6.20-6 1.03-5
8.30 15.30	H G	9.40-9 1.44-8	5.95-8 9.40-8	2.67-7 3.83-7	8.85-7 1.41-6	1.91-6 3.30-6	2.78-6 5.05-6	5.48-6 1.03-5	7.25-6 1.38-5
9.00 15.00	H G	1.70-8 3.08-8	9.20-8 1.77-7	3.70-7 6.35-7	1.18-6 2.20-6	2.40-6 4.80-6	3.38-6 6.90-6	6.42-6 1.31-5	8.20-6 1.69-5
9.30 14.30	H G	2.80-8 5.60-8	1.28-7 2.93-7	4.68-7 9.25-7	1.44-6 3.10-6	2.78-6 6.10-6	4.00-6 8.55-6	7.20-6 1.54-5	9.00-6 1.96-5
10.00 14.00	H G	4.15-8 8.60-8	1.61-7 4.35-7	5.52-7 1.21-6	1.65-6 3.95-6	3.03-6 6.95-6	4.60-6 1.01-5	7.75-6 1.72-5	9.65-6 2.15-5
10.30 13.30	H G	5.50-8 1.17-7	1.88-7 5.75-7	6.25-7 1.47-6	1.82-6 4.68-6	3.22-6 7.55-6	5.10-6 1.14-5	8.15-6 1.85-5	1.02-5 2.30-5
11.00 13.00	H G	6.50-8 1.44-7	2.07-7 6.90-7	6.75-7 1.68-6	1.94-6 5.23-6	3.38-6 7.90-6	5.50-6 1.23-5	8.42-6 1.94-5	1.06-5 2.40-5
12.00 12.00	H G	7.30-8 1.68-7	2.21-7 8.02-7	7.15-7 1.87-6	2.03-6 5.70-6	3.48-6 8.10-6	5.85-6 1.32-5	8.65-6 2.00-5	1.09-5 2.48-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
9.40-9	1.29-8	3.17-8	6.45-8	6.20-8	8.20-8	9.80-8	1.18-7	1.04-7
6.70-8	1.12-7	2.92-7	5.80-7	8.60-7	1.05-6	1.10-6	1.27-6	1.17-6
3.53-7	5.70-7	1.28-6	2.28-6	2.74-6	3.41-6	3.55-6	4.00-6	3.84-6
1.01-6	1.62-6	2.92-6	3.40-6	4.75-6	6.00-6	6.40-6	9.20-6	8.19-6
1.09-6	1.59-6	2.89-6	4.88-6	5.60-6	6.38-6	6.55-6	7.25-6	6.69-6
1.63-6	2.41-6	4.38-6	5.50-6	7.05-6	8.50-6	9.10-6	1.27-5	1.16-5
2.25-6	3.09-6	5.00-6	7.90-6	8.55-6	9.02-6	9.15-6	1.02-5	8.92-6
2.67-6	3.65-6	6.20-6	8.97-6	1.06-5	1.20-5	1.28-5	1.72-5	1.62-5
3.65-6	4.95-6	7.30-6	1.08-5	1.12-5	1.16-5	1.13-5	1.27-5	1.08-5
4.30-6	5.50-6	8.70-6	1.39-5	1.53-5	1.68-5	1.77-5	2.31-5	2.15-5
5.15-6	7.05-6	9.40-6	1.32-5	1.36-5	1.38-5	1.33-5	1.51-5	1.27-5
6.70-6	8.18-6	1.22-5	1.98-5	2.09-5	2.27-5	2.37-5	2.99-5	2.84-5
6.70-6	9.05-6	1.13-5	1.53-5	1.56-5	1.57-5	1.50-5	1.72-5	1.44-5
1.00-5	1.20-5	1.69-5	2.57-5	2.71-5	2.97-5	3.04-5	3.75-5	3.60-5
8.18-6	1.05-5	1.31-5	1.70-5	1.73-5	1.72-5	1.63-5	1.88-5	1.59-5
1.40-5	1.68-5	2.30-5	3.12-5	3.28-5	3.60-5	3.72-5	4.50-5	4.36-5
9.60-6	1.18-5	1.48-5	1.84-5	1.85-5	1.87-5	1.74-5	2.01-5	1.73-5
1.83-5	2.19-5	2.92-5	3.62-5	3.79-5	4.15-5	4.27-5	5.15-5	5.00-5
1.08-5	1.29-5	1.63-5	1.97-5	1.94-5	1.96-5	1.83-5	2.11-5	1.85-5
2.27-5	2.63-5	3.51-5	4.10-5	4.25-5	4.60-5	4.70-5	5.58-5	5.36-5
1.17-5	1.39-5	1.76-5	2.05-5	2.00-5	2.01-5	1.91-5	2.19-5	1.97-5
2.60-5	2.99-5	4.00-5	4.54-5	4.65-5	4.95-5	5.05-5	5.95-5	5.59-5
1.24-5	1.48-5	1.88-5	2.13-5	2.07-5	2.04-5	1.97-5	2.25-5	2.07-5
2.89-5	3.27-5	4.38-5	4.90-5	5.00-5	5.17-5	5.35-5	6.23-5	5.79-5
1.31-5	1.53-5	1.99-5	2.20-5	2.12-5	2.07-5	2.02-5	2.30-5	2.17-5
3.12-5	3.48-5	4.70-5	5.21-5	5.28-5	5.32-5	5.58-5	6.45-5	5.87-5
1.35-5	1.58-5	2.08-5	2.25-5	2.16-5	2.09-5	2.06-5	2.33-5	2.23-5
3.28-5	3.65-5	4.90-5	5.47-5	5.52-5	5.41-5	5.75-5	6.65-5	5.99-5
1.39-5	1.60-5	2.15-5	2.29-5	2.19-5	2.11-5	2.08-5	2.34-5	2.28-5
3.41-5	3.78-5	5.05-5	5.70-5	5.70-5	5.48-5	5.85-5	6.78-5	6.03-5

Table 12: August

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
4.30 19.30	H				3.55-10	7.50-10	1.06-9	1.95-9	3.52-9
5.00 19.00	H			3.31-10	1.06-9	2.95-9	5.30-9	1.30-8	2.45-8
5.30 18.30	H		1.95-10	9.20-10	3.37-9	1.13-8	2.58-8	7.20-8	1.53-7
5.45+	G			1.50-9	1.00-8	5.65-8	1.14-7	3.10-7	7.20-7
6.00	H		4.80-10	2.43-9	1.C5-8	3.72-8	9.90-8	2.92-7	5.65-7
18.00	G			2.48-9	1.63-8	7.90-8	1.63-7	4.40-7	9.60-7
6.30	H		1.24-9	6.50-9	3.25-8	1.14-7	2.77-7	7.58-7	1.40-6
17.30	G		(1.19-9)	6.85-9	4.35-8	1.62-7	3.33-7	9.10-7	1.67-6
17.15−	G		(1.99-9)	1.14-8	7.00-8	2.30-7	4.70-7	1.29-6	2.18-6
7.00	H		3.20-9	1.66-8	8.80-8	2.74-7	6.10-7	1.47-6	2.55-6
17.00	G		3.27-9	1.84-8	1.12-7	3.23-7	6.60-7	1.78-6	2.87-6
7.30	H		8.30-9	4.00-8	1.99-7	5.60-7	1.12-6	2.38-6	3.85-6
16.30	G		8.80-9	4.65-8	2.55-7	6.30-7	1.27-6	3.17-6	4.70-6
8.00	H	3.15-9	1.94-8	8.90-8	3.81-7	9.90-7	1.72-6	3.48-6	5.20-6
16.00	G	(3.15-9)	2.17-8	1.08-7	5.08-7	1.17-6	2.23-6	5.05-6	7.15-6
8.30	H	5.90-9	3.95-3	1.74-7	6.50-7	1.48-6	2.37-6	4.57-6	6.45-6
15.30	G	7.60-9	4.97-8	2.33-7	9.15-7	2.08-6	3.58-6	7.60-6	1.03-5
9.00	H	1.04-8	6.70-8	2.83-7	9.40-7	1.95-6	3.00-6	5.55-6	7.50-6
15.00	G	1.72-8	1.03-7	4.25-7	1.52-6	3.32-6	5.25-6	1.04-5	1.37-5
9.30	H	1.76-8	9.95-8	3.85-7	1.20-6	2.38-6	3.58-6	6.38-6	8.35-6
14.30	G	3.62-8	1.93-7	6.80-7	2.29-6	4.78-6	7.05-6	1.32-5	1.68-5
10.00	H	2.77-8	1.32-7	4.75-7	1.44-6	2.74-6	4.12-6	7.02-6	9.00-6
14.00	G	6.55-8	3.18-7	9.90-7	3.20-6	6.10-6	8.80-6	1.55-5	1.97-5
10.30	H	3.90-8	1.61-7	5.45-7	1.63-6	3.00-6	4.55-6	7.45-6	9.55-6
13.30	G	9.70-8	4.53-7	1.28-6	4.05-6	7.25-6	1.02-5	1.73-5	2.15-5
11.00	H	4.95-8	1.84-7	6.00-7	1.78-6	3.20-6	4.87-6	7.75-6	9.95-6
13.00	G	1.27-7	5.75-7	1.53-6	4.75-6	8.00-6	1.14-5	1.88-5	2.28-5
12.00	H	5.80-8	2.04-7	6.45-7	1.90-6	3.34-6	5.15-6	8.00-6	1.03-5
12.00	G	1.54-7	6.85-7	1.74-6	5.27-6	8.60-6	1.23-5	1.98-5	2.38-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
4.25-9	5.30-9	1.04-8	2.32-8	1.93-8	2.40-8	1.77-8	2.10-8	1.86-8
4.13-8	6.70-8	1.70-7	3.60-7	5.20-7	6.60-7	6.70-7	7.90-7	7.12-7
3.05-7	5.05-7	1.14-6	2.00-6	2.37-6	3.00-6	3.13-6	3.55-6	3.43-6
1.30-6	1.96-6	3.59-6	4.25-6	5.42-6	6.80-6	7.30-6	1.04-5	9.36-6
1.06-6	1.59-6	2.91-6	4.65-6	5.25-6	6.05-6	6.25-6	6.90-6	6.42-6
1.67-6	2.46-6	4.40-6	5.40-6	6.70-6	8.20-6	8.78-6	1.23-5	1.12-5
2.25-6	3.20-6	5.10-6	7.70-6	8.35-6	8.80-6	9.00-6	9.95-6	8.66-6
2.75-6	3.75-6	6.25-6	8.80-6	1.02-5	1.17-5	1.25-5	1.68-5	1.58-5
3.55-6	4.58-6	7.40-6	1.11-5	1.22-5	1.38-5	1.48-5	1.95-5	1.81-5
3.70-6	5.10-6	7.40-6	1.08-5	1.12-5	1.14-5	1.13-5	1.26-5	1.07-5
4.48-6	5.68-6	8.90-6	1.40-5	1.50-5	1.66-5	1.74-5	2.28-5	2.12-5
5.25-6	7.25-6	9.45-6	1.32-5	1.36-5	1.37-5	1.33-5	1.50-5	1.26-5
7.05-6	8.45-6	1.24-5	1.98-5	2.07-5	2.25-5	2.35-5	2.97-5	2.82-5
6.80-6	9.05-6	1.14-5	1.52-5	1.55-5	1.55-5	1.49-5	1.70-5	1.43-5
1.03-5	1.21-5	1.68-5	2.55-5	2.68-5	2.93-5	3.00-5	3.70-5	3.55-5
8.30-6	1.07-5	1.32-5	1.68-5	1.71-5	1.71-5	1.63-5	1.87-5	1.58-5
1.44-5	1.67-5	2.24-5	3.07-5	3.23-5	3.55-5	3.67-5	4.45-5	4.32-5
9.60-6	1.20-5	1.47-5	1.82-5	1.83-5	1.85-5	1.73-5	1.99-5	1.71-5
1.85-5	2.15-5	2.85-5	3.57-5	3.70-5	4.07-5	4.20-5	5.05-5	4.90-5
1.07-5	1.30-5	1.62-5	1.93-5	1.92-5	1.94-5	1.81-5	2.08-5	1.82-5
2.26-5	2.62-5	3.42-5	4.00-5	4.13-5	4.50-5	4.60-5	5.50-5	5.33-5
1.14-5	1.38-5	1.73-5	2.02-5	1.98-5	1.99-5	1.88-5	2.17-5	1.93-5
2.60-5	2.99-5	3.88-5	4.35-5	4.48-5	4.81-5	4.90-5	5.80-5	5.51-5
1.21-5	1.46-5	1.83-5	2.09-5	2.03-5	2.03-5	1.93-5	2.22-5	2.01-5
2.87-5	3.25-5	4.25-5	4.65-5	4.75-5	5.05-5	5.15-5	6.05-5	5.69-5
1.27-5	1.49-5	1.91-5	2.13-5	2.07-5	2.04-5	1.97-5	2.25-5	2.07-5
3.05-5	3.45-5	4.50-5	4.88-5	5.00-5	5.17-5	5.35-5	6.22-5	5.79-5
1.30-5	1.53-5	1.98-5	2.18-5	2.10-5	2.07-5	2.00-5	2.28-5	2.13-5
3.18-5	3.58-5	4.70-5	5.05-5	5.15-5	5.25-5	5.45-5	6.37-5	5.86-5

Table 13: September

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
6.00 / 18.00	H			6.10-10	2.15-9	5.90-9	1.15-8	2.88-8	5.60-8
6.30 / 17.30	H		4.27-10	1.78-9	7.35-9	2.47-8	5.50-8	1.64-7	3.08-7
7.00^{+}	H		1.06-9	5.05-9	2.28-8	8.50-8	1.95-7	5.40-7	9.75-7
17.00	G		(1.00-9)	6.50-9	3.02-8	1.14-7	2.79-7	7.10-7	1.36-6
7.30	H		2.55-9	1.34-8	6.50-8	2.20-7	4.95-7	1.15-6	2.04-6
16.30^{-}	G		2.62-9	1.48-8	8.90-8	2.48-7	5.45-7	1.37-6	2.28-6
8.00	H		6.05-9	3.25-8	1.55-7	4.63-7	9.15-7	1.99-6	3.28-6
16.00	G		6.65-9	3.62-8	2.05-7	4.98-7	1.00-6	2.45-6	3.65-6
8.30	H		1.38-8	7.10-8	3.10-7	8.15-7	1.46-6	2.98-6	4.48-6
15.30	G		1.61-8	7.90-8	4.00-7	9.15-7	1.71-6	3.92-6	5.65-6
9.00	H	4.58-9	2.80-8	1.32-7	5.35-7	1.22-6	2.02-6	3.97-6	5.60-6
15.00	G	5.25-9	3.48-8	1.55-7	7.05-7	1.57-6	2.67-6	5.78-6	8.05-6
9.30	H	7.60-9	4.85-8	2.12-7	7.70-7	1.67-6	2.58-6	4.88-6	6.55-6
14.30	G	1.11-8	6.75-8	2.75-7	1.13-6	2.45-6	3.90-6	8.00-6	1.07-5
10.00	H	1.18-8	7.00-8	2.92-7	9.80-7	2.04-6	3.06-6	5.60-6	7.30-6
14.00	G	2.05-8	1.18-7	4.38-7	1.62-6	3.48-6	5.30-6	1.02-5	1.33-5
10.30	H	1.70-8	9.20-8	3.65-7	1.17-6	2.35-6	3.48-6	6.20-6	7.85-6
13.30	G	3.40-8	1.84-7	6.30-7	2.18-6	4.60-6	6.65-6	1.23-5	1.56-5
11.00	H	2.20-8	1.10-7	4.20-7	1.30-6	2.58-6	3.77-6	6.60-6	8.25-6
13.00	G	4.85-8	2.53-7	8.05-7	2.66-6	5.50-6	7.75-6	1.38-5	1.73-5
12.00	H	2.70-8	1.28-7	4.72-7	1.42-6	2.75-6	4.00-6	6.90-6	8.60-6
12.00	G	6.40-8	3.30-7	9.90-7	3.17-6	6.35-6	8.75-6	1.52-5	1.88-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
1.03-7	1.82-7	4.40-7	8.05-7	1.08-6	1.34-6	1.40-6	1.63-6	1.52-6
6.30-7	1.01-6	1.90-6	3.05-6	3.44-6	4.25-6	4.40-6	4.95-6	4.70-6
1.75-6	2.47-6	4.15-6	5.98-6	6.65-6	7.30-6	7.50-6	8.40-6	7.60-6
2.25-6	3.13-6	5.40-6	6.50-6	8.05-6	9.60-6	1.02-5	1.41-5	1.30-5
3.08-6	4.22-6	6.50-6	9.05-6	9.50-6	9.90-6	1.01-5	1.12-5	9.63-6
3.59-6	4.75-6	7.55-6	1.08-5	1.20-5	1.35-5	1.44-5	1.91-5	1.78-5
4.50-6	6.15-6	8.55-6	1.18-5	1.21-5	1.23-5	1.20-5	1.35-5	1.14-5
5.53-6	6.90-6	1.04-5	1.62-5	1.69-5	1.86-5	1.95-5	2.52-5	2.36-5
5.93-6	8.10-6	1.04-5	1.38-5	1.42-5	1.43-5	1.37-5	1.56-5	1.31-5
8.05-6	9.70-6	1.40-5	2.18-5	2.24-5	2.44-5	2.52-5	3.17-5	3.01-5
7.30-6	9.70-6	1.20-5	1.54-5	1.57-5	1.58-5	1.52-5	1.74-5	1.46-5
1.13-5	1.31-5	1.83-5	2.65-5	2.65-5	3.03-5	3.12-5	3.82-5	3.67-5
8.60-6	1.10-5	1.35-5	1.68-5	1.71-5	1.70-5	1.62-5	1.87-5	1.58-5
1.48-5	1.71-5	2.30-5	3.10-5	3.21-5	3.54-5	3.65-5	4.42-5	4.27-5
9.60-6	1.20-5	1.46-5	1.78-5	1.80-5	1.81-5	1.70-5	1.97-5	1.68-5
1.82-5	2.11-5	2.78-5	3.47-5	3.58-5	3.92-5	4.05-5	4.90-5	4.75-5
1.03-5	1.27-5	1.57-5	1.85-5	1.87-5	1.89-5	1.75-5	2.03-5	1.76-5
2.12-5	2.45-5	3.22-5	3.77-5	3.87-5	4.23-5	4.35-5	5.25-5	5.09-5
1.09-5	1.32-5	1.62-5	1.90-5	1.91-5	1.93-5	1.80-5	2.08-5	1.82-5
2.35-5	2.70-5	3.52-5	3.98-5	4.08-5	4.44-5	4.54-5	5.45-5	5.29-5
1.13-5	1.35-5	1.68-5	1.95-5	1.94-5	1.96-5	1.83-5	2.11-5	1.86-5
2.55-5	2.88-5	3.77-5	4.17-5	4.25-5	4.60-5	4.70-5	5.60-5	5.38-5

Table 14: October

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
6.30 17.30	H				1.03-9	2.40-9	4.15-9	8.65-9	1.38-8
7.00 17.00	H		3.18-10	9.68-10	3.46-9	1.04-8	2.07-8	5.40-8	1.07-7
7.30 16.30	H		7.10-10	2.67-9	1.17-8	3.90-8	8.90-8	2.60-7	4.72-7
8.00 16.00	H		1.52-9	6.70-9	3.47-8	1.14-7	2.68-7	7.00-7	1.19-6
15.45⁻	G		2.00-9	1.14-8	7.35-8	2.16-7	4.70-7	1.17-6	1.94-6
8.30⁺ 15.30	H G		3.12-9 (3.10-9)	1.52-8 1.77-8	8.50-8 1.11-7	2.56-7 2.98-7	5.60-7 6.20-7	1.31-6 1.52-6	2.16-6 2.40-6
9.00 15.00	H G		6.00-9 7.00-9	3.05-8 3.84-8	1.68-7 2.14-7	4.70-7 5.20-7	9.40-7 1.02-6	2.01-6 2.41-6	3.20-6 3.52-6
9.30 14.30	H G		1.11-8 1.42-8	5.75-8 7.50-8	2.88-7 3.60-7	7.55-7 8.40-7	1.38-6 1.54-6	2.78-6 3.54-6	4.28-6 4.92-6
10.00 14.00	H G		1.83-8 2.50-8	9.50-8 1.23-7	4.23-7 5.50-7	1.08-6 1.24-6	1.79-6 2.17-6	3.45-6 4.72-6	5.10-6 6.45-6
10.30 13.30	H G	5.05-9 5.70-9	2.82-8 3.95-8	1.38-7 1.78-7	5.70-7 7.55-7	1.35-6 1.68-6	2.15-6 2.82-6	4.00-6 5.90-6	5.75-6 7.97-6
11.00 13.00	H G	6.38-9 7.95-9	3.85-8 5.40-8	1.78-7 2.32-7	6.85-7 9.50-7	1.57-6 2.07-6	2.38-6 3.37-6	4.43-6 6.95-6	6.20-6 9.20-6
12.00 12.00	H G	7.75-9 1.04-8	4.95-8 6.95-8	2.14-7 2.83-7	7.90-7 1.14-6	1.74-6 2.45-6	2.60-6 3.87-6	4.78-6 7.75-6	6.55-6 1.03-5

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
2.32-8	3.33-8	8.80-8	1.78-7	2.60-7	3.10-7	3.35-7	4.00-7	3.57-7
2.10-7	3.47-7	8.00-7	1.37-6	1.68-6	2.14-6	2.24-6	2.57-6	2.44-6
9.60-7	1.38-6	2.49-6	3.88-6	4.28-6	5.10-6	5.32-6	5.90-6	5.55-6
2.12-6	2.80-6	4.45-6	6.60-6	7.20-6	7.80-6	8.00-6	8.80-6	7.85-6
3.10-6	4.15-6	6.75-6	9.05-6	1.02-5	1.18-5	1.26-5	1.70-5	1.56-5
3.35-6 3.82-6	4.47-6 4.90-6	6.55-6 7.80-6	9.20-6 1.10-5	9.65-6 1.23-5	1.01-5 1.38-5	1.02-5 1.47-5	1.12-5 1.94-5	9.63-6 1.80-5
4.50-6 5.50-6	6.15-6 6.75-6	8.40-6 1.02-5	1.14-5 1.53-5	1.17-5 1.63-5	1.20-5 1.78-5	1.18-5 1.88-5	1.32-5 2.44-5	1.12-5 2.29-5
5.65-6 7.50-6	7.70-6 8.95-6	1.00-5 1.29-5	1.31-5 1.99-5	1.35-5 2.04-5	1.37-5 2.23-5	1.32-5 2.33-5	1.49-5 2.93-5	1.25-5 2.78-5
6.65-6 9.40-6	8.90-6 1.13-5	1.13-5 1.58-5	1.44-5 2.34-5	1.47-5 2.42-5	1.48-5 2.63-5	1.42-5 2.72-5	1.62-5 3.38-5	1.36-5 3.21-5
7.45-6 1.14-5	9.80-6 1.34-5	1.22-5 1.84-5	1.54-5 2.63-5	1.57-5 2.74-5	1.57-5 3.00-5	1.51-5 3.08-5	1.72-5 3.78-5	1.44-5 3.63-5
8.00-6 1.28-5	1.05-5 1.52-5	1.28-5 2.06-5	1.60-5 2.83-5	1.63-5 2.95-5	1.63-5 3.24-5	1.57-5 3.35-5	1.79-5 4.05-5	1.51-5 3.89-5
8.50-6 1.42-5	1.09-5 1.69-5	1.34-5 2.26-5	1.66-5 3.00-5	1.68-5 3.13-5	1.68-5 3.43-5	1.60-5 3.54-5	1.84-5 4.30-5	1.55-5 4.17-5

Table 15: November

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
7.00 17.00	H				1.32-9	2.05-9	3.25-9	5.95-9	7.70-9
7.30 16.30	H			1.40-9	4.00-9	8.35-9	1.62-8	3.38-8	5.80-8
8.00 16.00	H		7.45-10	3.13-9	1.11-8	2.95-8	6.60-8	1.53-7	3.03-7
8.30 15.30	H		1.35-9	6.60-9	2.70-8	8.95-8	2.05-7	5.00-7	9.20-7
15.15$^-$	G		8.50-10	5.35-9	2.92-8	1.73-7	3.78-7	1.02-6	1.36-6
9.00 15.00	H		2.33-9	1.27-8	5.75-8	2.07-7	4.55-7	1.11-6	1.78-6
9.15$^+$	G		1.96-9	1.28-8	7.55-8	3.38-7	7.00-7	1.77-6	2.38-6
9.30	H		3.80-9	2.23-8	1.12-7	3.77-7	7.80-7	1.83-6	2.80-6
14.30	G		(2.75-9	1.78-8	1.12-7)	4.30-7	8.90-7	2.13-6	2.97-6
10.00	H		5.75-9	3.60-8	1.82-7	5.82-7	1.13-6	2.55-6	3.77-6
14.00	G		(5.30-9	3.37-8)	2.12-7	6.65-7	1.36-6	2.95-6	4.35-6
10.30	H		8.05-9	5.15-8	2.60-7	7.75-7	1.46-6	3.19-6	4.60-6
13.30	G	1.43-9	8.80-9	5.45-8	3.25-7	9.00-7	1.82-6	3.71-6	5.65-6
11.00	H		1.03-8	6.60-8	3.28-7	9.35-7	1.73-6	3.67-6	5.20-6
13.00	G	1.89-9	1.28-8	7.60-8	4.35-7	1.09-6	2.23-6	4.30-6	6.65-6
12.00	H		1.25-8	8.05-8	3.94-7	1.08-6	1.95-6	4.05-6	5.70-6
12.00	G	2.41-9	1.70-8	9.80-8	5.35-7	1.27-6	2.58-6	4.83-6	7.45-6

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
1.40-8	1.67-8	4.48-8	9.50-8	4.90-8	6.00-8	5.00-8	6.40-8	5.66-8
1.13-7	1.78-7	4.13-7	7.85-7	1.04-6	1.18-6	1.25-6	1.32-6	1.20-6
5.75-7	9.20-7	1.83-6	2.90-6	3.57-6	3.65-6	3.80-6	4.35-6	4.20-6
1.70-6	2.45-6	4.23-6	5.85-6	6.60-6	6.65-6	6.75-6	7.85-6	7.35-6
2.55-6	3.58-6	6.25-6	8.20-6	8.80-6	9.20-6	9.20-6	1.18-5	1.09-5
3.14-6	4.45-6	6.90-6	8.70-6	9.40-6	9.40-6	9.15-6	1.05-5	9.40-6
4.13-6	5.65-6	8.95-6	1.19-5	1.32-5	1.36-5	1.37-5	1.72-5	1.60-5
4.60-6	6.35-6	9.25-6	1.14-5	1.17-5	1.18-5	1.13-5	1.27-5	1.10-5
4.90-6	6.75-6	1.04-5	1.38-5	1.51-5	1.55-5	1.57-5	1.94-5	1.80-5
5.90-6	7.80-6	1.11-5	1.36-5	1.38-5	1.38-5	1.30-5	1.44-5	1.23-5
6.70-6	9.25-6	1.35-5	1.77-5	1.94-5	1.94-5	2.02-5	2.40-5	2.23-5
7.05-6	8.95-6	1.25-5	1.54-5	1.55-5	1.54-5	1.44-5	1.57-5	1.33-5
8.25-6	1.13-5	1.60-5	2.11-5	2.29-5	2.28-5	2.40-5	2.80-5	2.63-5
7.85-6	9.65-6	1.35-5	1.67-5	1.67-5	1.65-5	1.54-5	1.66-5	1.40-5
9.50-6	1.29-5	1.80-5	2.36-5	2.55-5	2.55-5	2.68-5	3.08-5	2.90-5
8.55-6	1.02-5	1.43-5	1.78-5	1.76-5	1.70-5	1.62-5	1.73-5	1.45-5
1.05-5	1.41-5	1.96-5	2.55-5	2.74-5	2.78-5	2.91-5	3.32-5	3.12-5

Table 16: December

LAT	λ:	297.5	300.0	302.5	305.0	307.5	310.0	312.5	315.0
7.30 16.30	H				1.36-9	2.57-9	4.35-9	8.00-9	1.29-8
8.00 16.00	H			1.16-9	3.68-9	8.00-9	1.72-8	4.10-8	7.40-8
8.30 15.30	H			2.48-9	8.90-9	2.37-8	5.65-8	1.60-7	3.03-7
9.00	H		7.75-10	4.80-9	1.93-8	6.10-8	1.50-7	4.25-7	8.00-7
15.00	G		(5.00-10	2.30-9	9.80-9	5.60-8	1.34-7)	4.85-7	(8.00-7)
9.30$^+$	H		1.33-9	8.30-9	3.75-8	1.30-7	3.12-7	8.05-7	1.51-6
14.30	G		(1.00-9	4.95-9	2.75-8	1.35-7	3.05-7)	1.00-6	(1.50-6)
10.00	H		2.08-9	1.31-8	6.35-8	2.22-7	5.05-7	1.24-6	2.20-6
14.00	G		(1.74-9	9.15-9	5.66-8)	2.37-7	5.36-7	1.52-6	2.24-6
10.30	H		2.99-9	1.85-8	9.40-8	3.20-7	7.05-7	1.68-6	2.82-6
13.30	G		(2.73-9	1.50-8)	1.00-7	3.50-7	7.90-7	2.03-6	3.13-6
11.00	H		3.88-9	2.37-8	1.25-7	4.05-7	8.75-7	2.04-6	3.28-6
13.00	G		(3.80-9	2.12-8)	1.43-7	4.58-7	1.03-6	2.44-6	3.87-6
12.00	H		4.80-9	2.88-8	1.54-7	4.85-7	1.03-6	2.34-6	3.70-6
12.00	G		5.00-9	(2.78-8)	1.87-7	5.60-7	1.23-6	2.82-6	4.55-6

317.5	320.0	325.0	330.0	340.0	350.0	360.0	370.0	380.0
2.22-8	3.15-8	7.50-8	1.38-7	1.35-7	1.60-7	1.60-7	1.80-7	1.59-7
1.48-7	2.37-7	5.50-7	1.01-6	1.40-6	1.54-6	1.65-6	1.78-6	1.64-6
6.05-7	9.25-7	1.89-6	3.12-6	3.85-6	4.13-6	4.13-6	4.80-6	4.61-6
1.45-6	2.12-6	3.77-6	5.75-6	6.60-6	6.60-6	6.70-6	7.80-6	7.30-6
1.50-6	2.37-6	4.40-6	6.80-6	6.80-6	6.90-6	7.20-6	8.90-6	8.10-6
2.53-6	3.67-6	5.80-6	8.20-6	9.00-6	8.95-6	8.80-6	1.05-5	9.45-6
2.67-6	3.83-6	6.55-6	9.55-6	1.02-5	1.08-5	1.07-5	1.36-5	1.25-5
3.65-6	5.10-6	7.70-6	1.04-5	1.10-5	1.10-5	1.05-5	1.18-5	1.03-5
3.80-6	5.42-6	8.83-6	1.22-5	1.34-5	1.41-5	1.41-5	1.77-5	1.66-5
4.55-6	6.25-6	9.20-6	1.23-5	1.25-5	1.25-5	1.18-5	1.33-5	1.14-5
4.92-6	7.05-6	1.11-5	1.51-5	1.65-5	1.68-5	1.71-5	2.10-5	1.96-5
5.20-6	7.00-6	1.03-5	1.37-5	1.37-5	1.36-5	1.28-5	1.43-5	1.22-5
5.85-6	8.38-6	1.28-5	1.73-5	1.88-5	1.90-5	1.96-5	2.36-5	2.20-5
5.75-6	7.65-6	1.11-5	1.47-5	1.46-5	1.44-5	1.37-5	1.50-5	1.27-5
6.70-6	9.60-6	1.44-5	1.92-5	2.10-5	2.10-5	2.18-5	2.58-5	2.40-5

LIST OF ILLUSTRATIONS

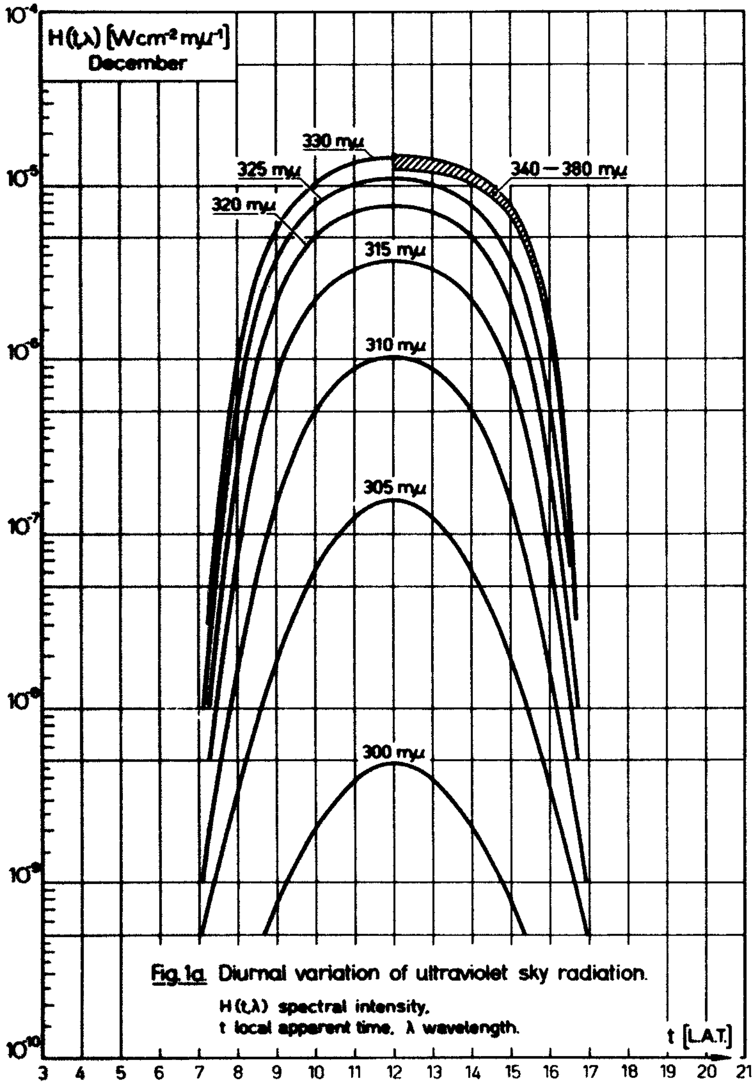

Fig. 1a Diurnal variation of ultraviolet sky radiation.
$H(t,\lambda)$ spectral intensity,
t local apparent time, λ wavelength.

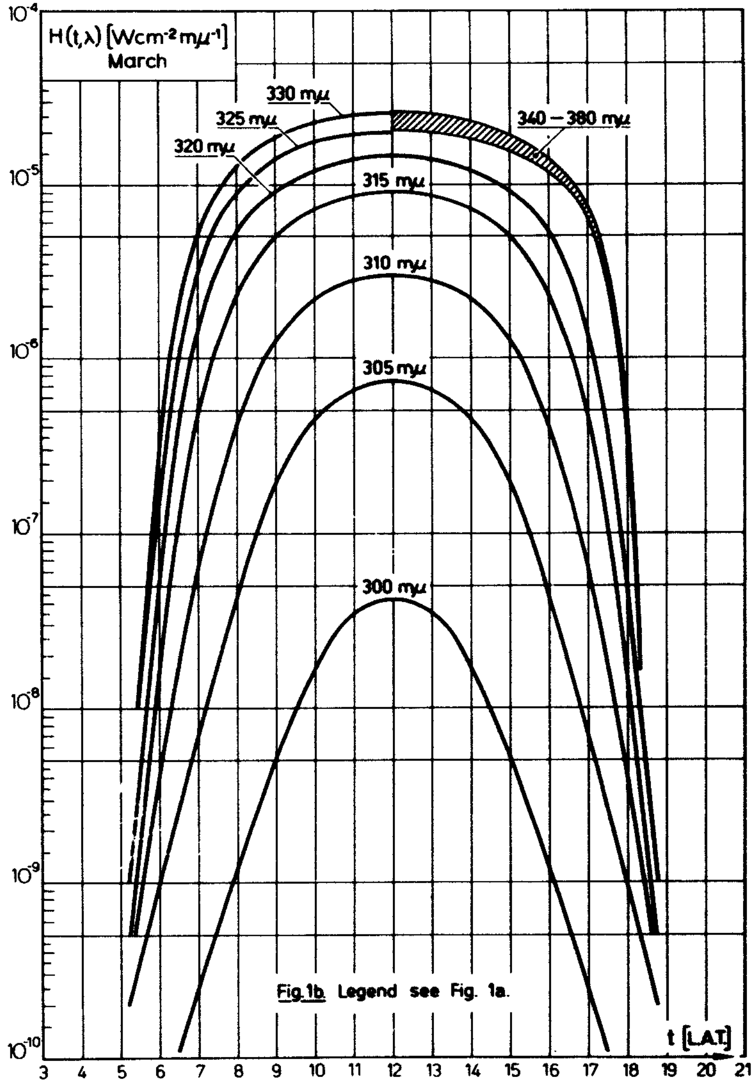

Fig. 1b Legend see Fig. 1a.

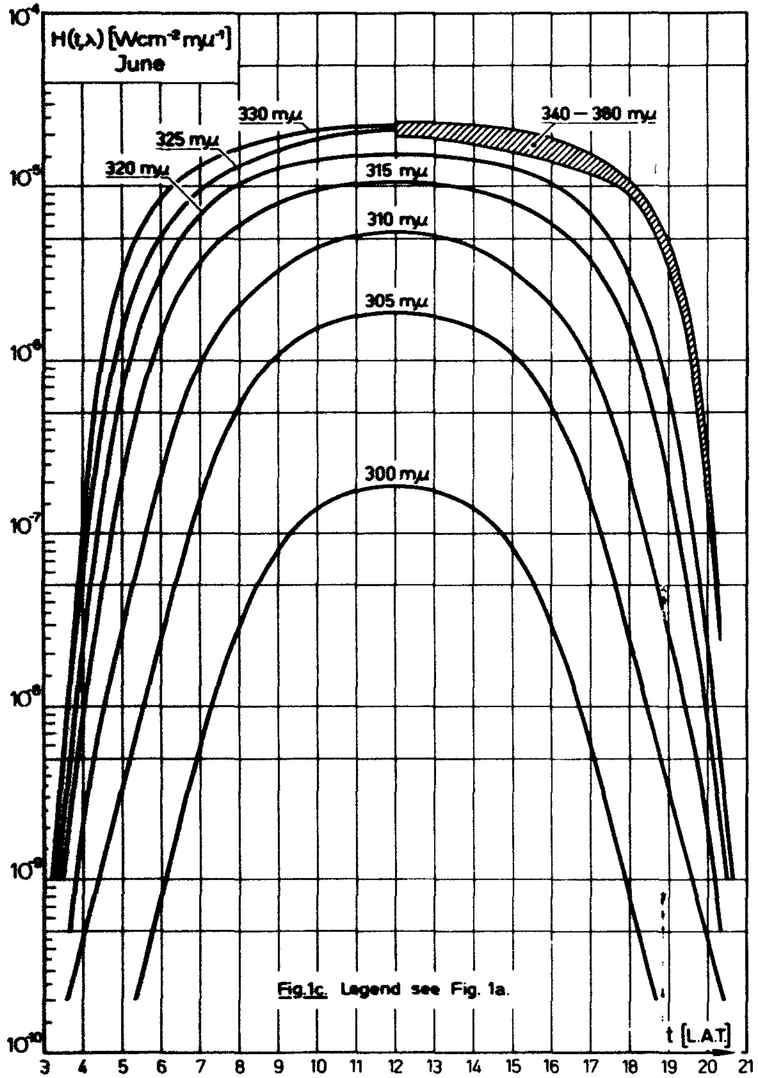

Fig. 1c. Legend see Fig. 1a.

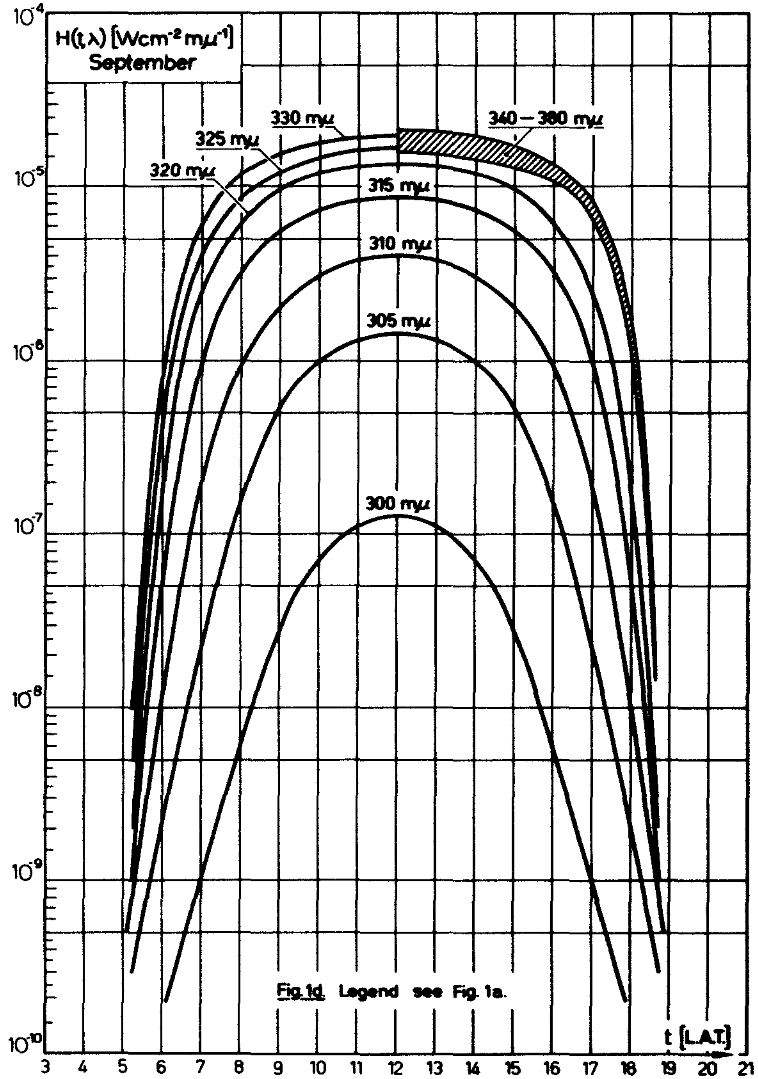

Fig. 1d. Legend see Fig. 1a.

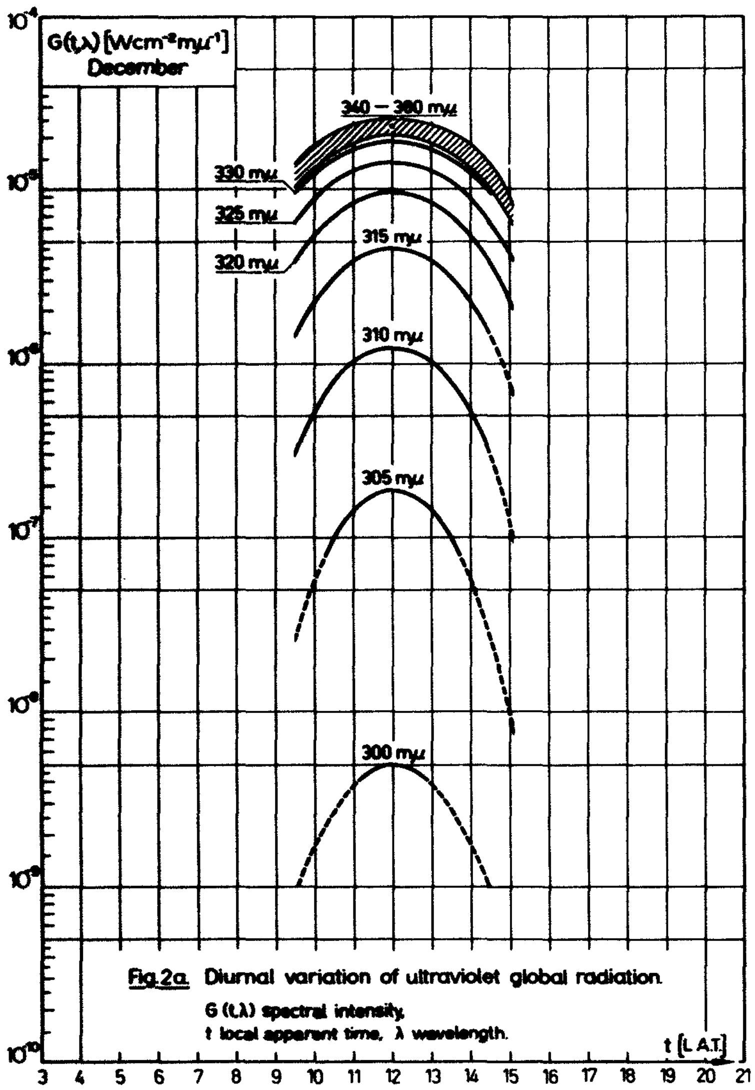

Fig.2a. Diurnal variation of ultraviolet global radiation.
G (t,λ) spectral intensity,
t local apparent time, λ wavelength.

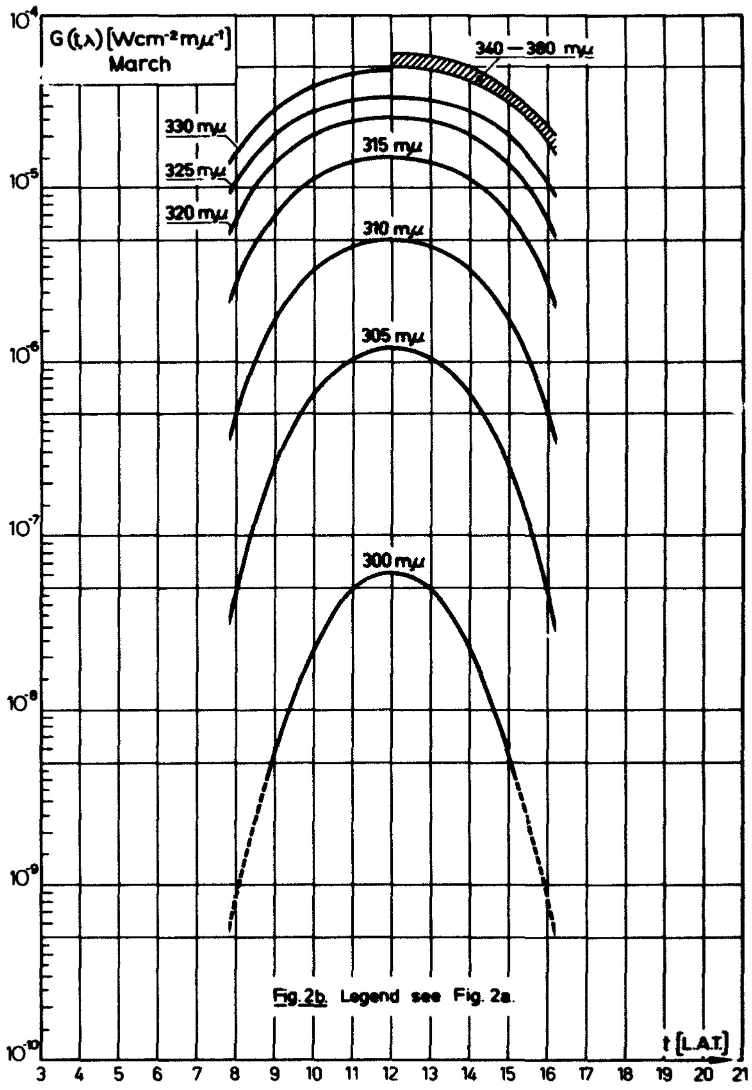

Fig.2b. Legend see Fig. 2a.

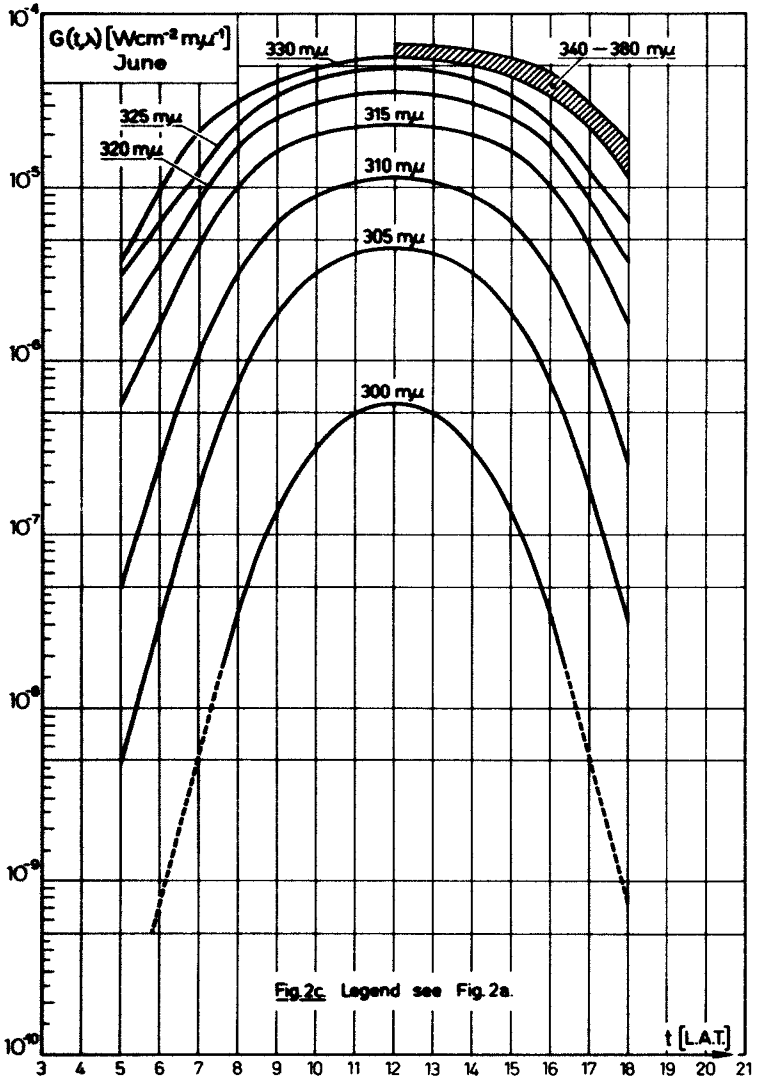

Fig. 2c. Legend see Fig. 2a.

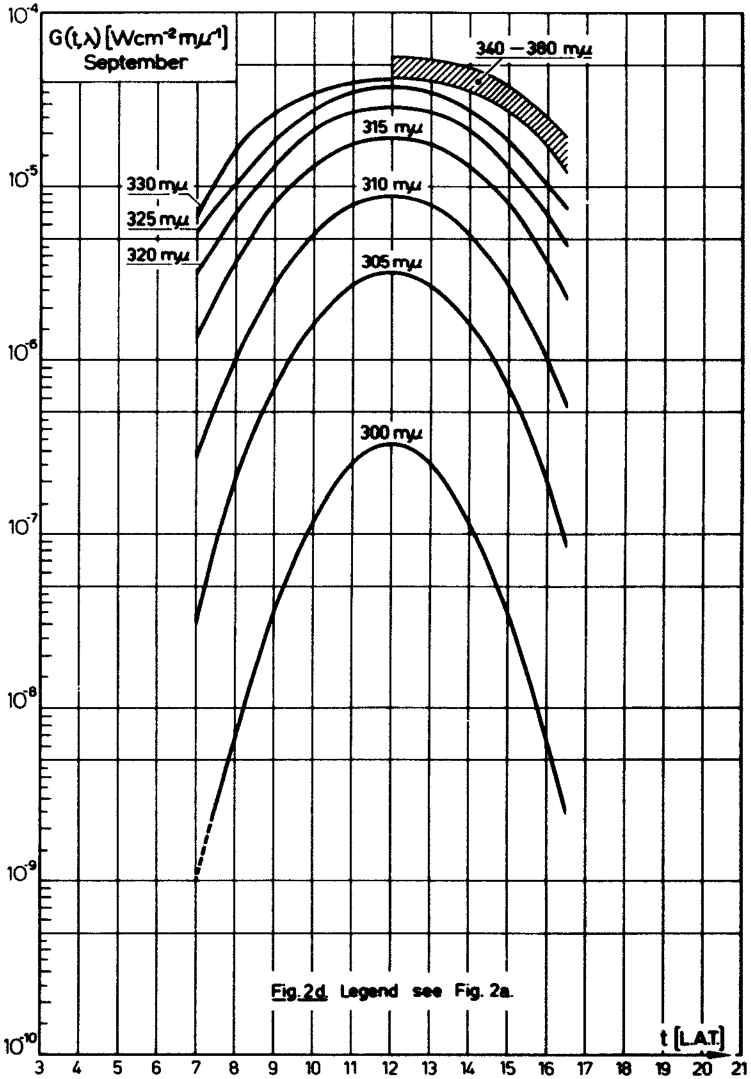

Fig. 2d. Legend see Fig. 2a.

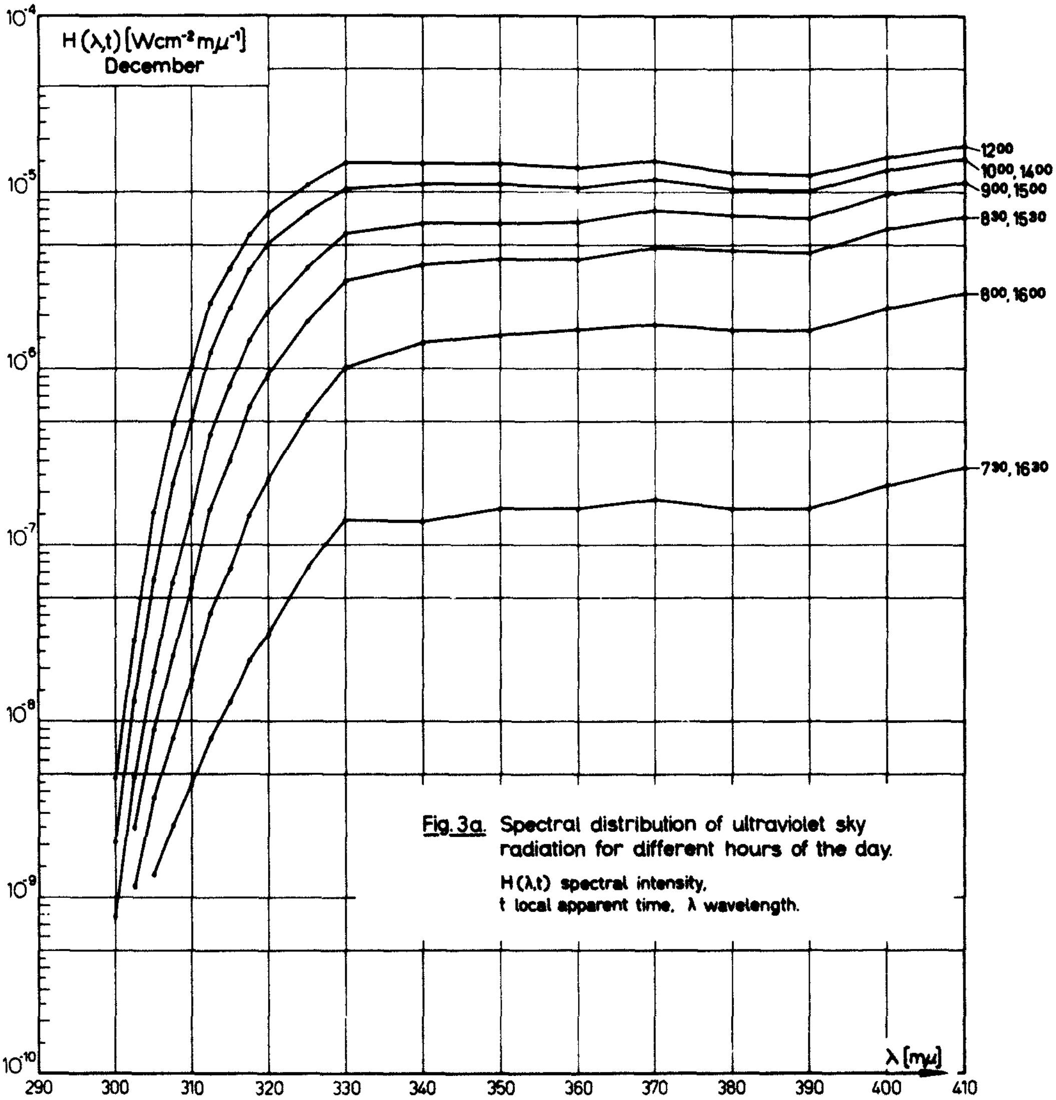

Fig. 3a. Spectral distribution of ultraviolet sky radiation for different hours of the day.

H (λ,t) spectral intensity,
t local apparent time, λ wavelength.

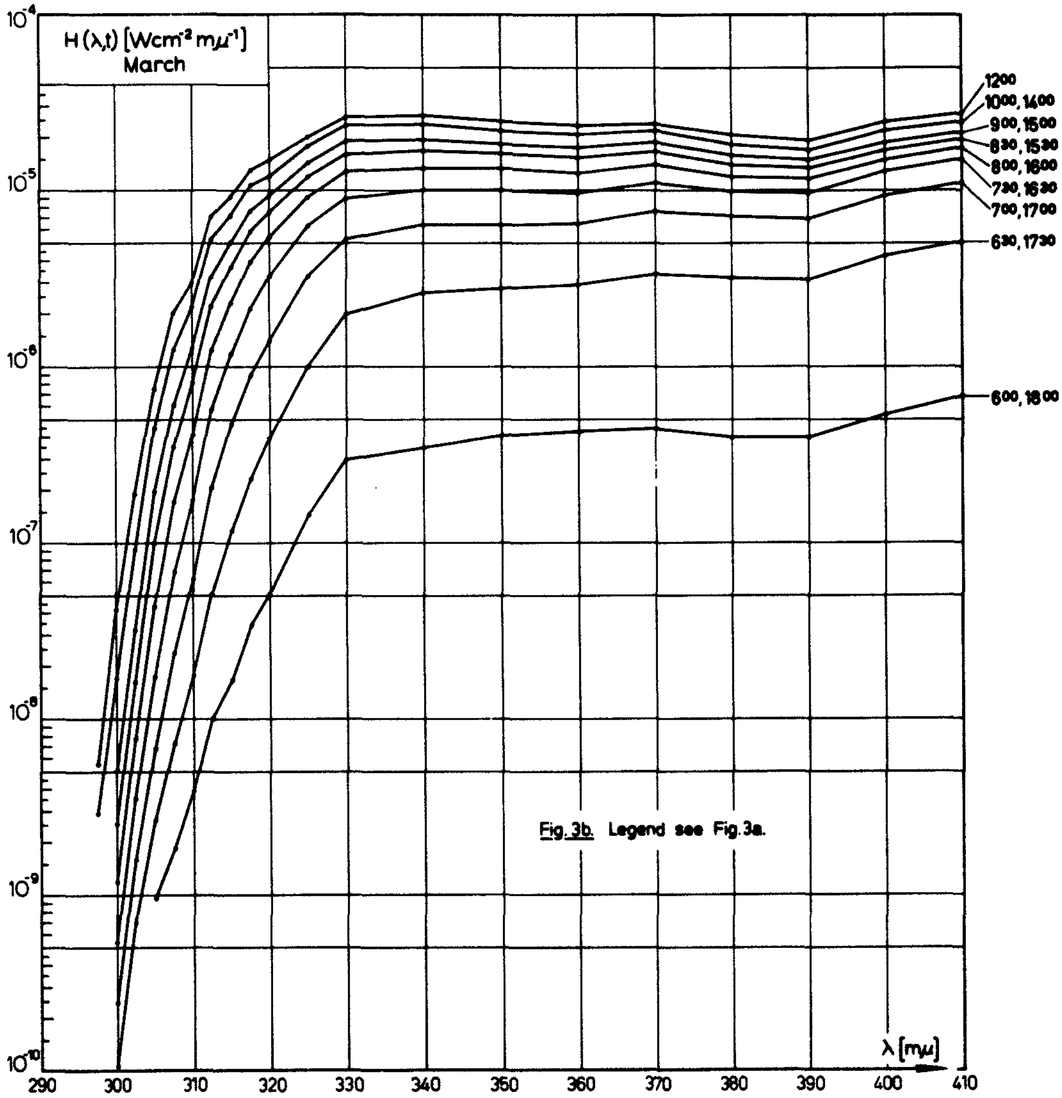

Fig. 3b. Legend see Fig. 3a.

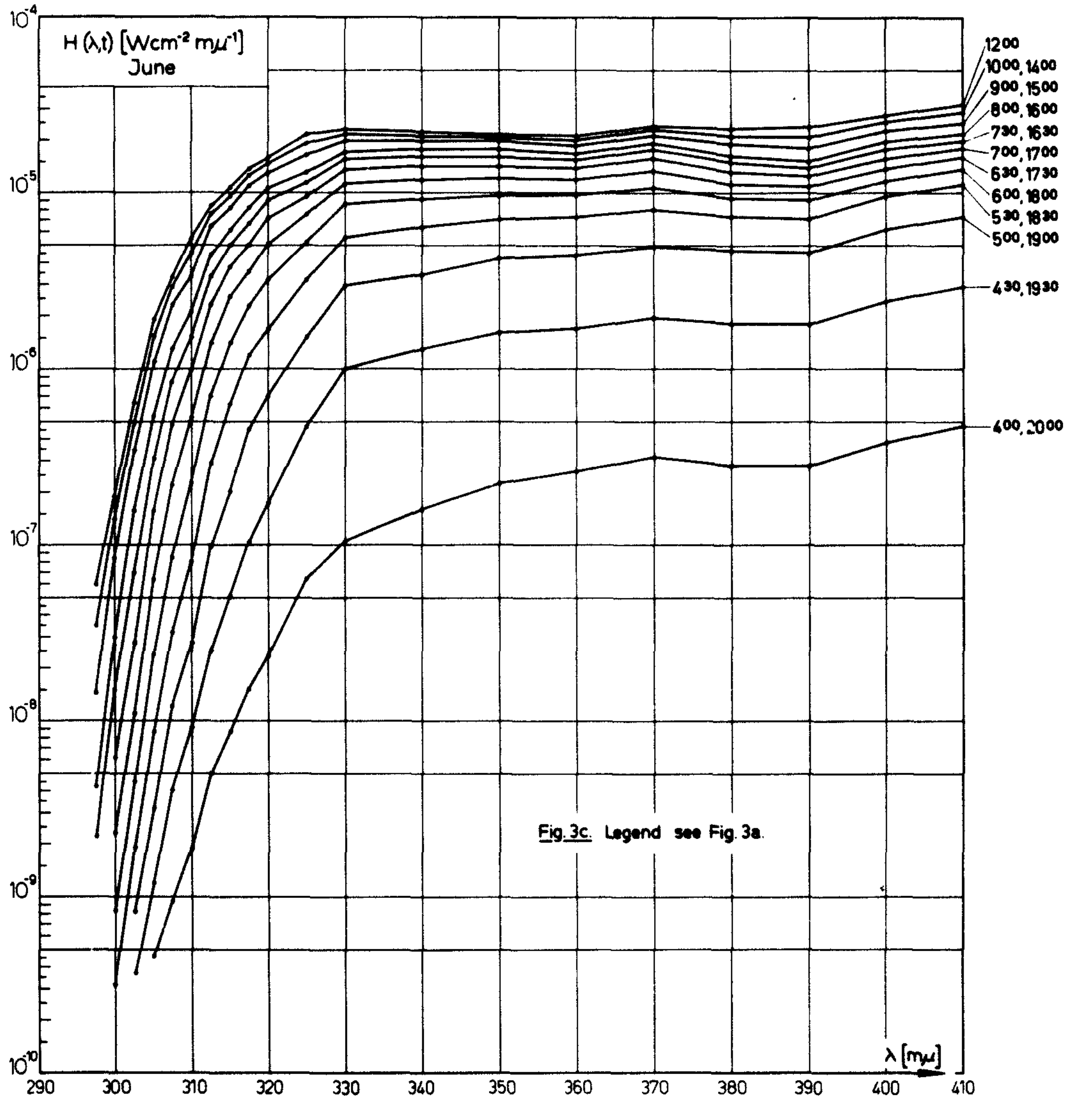

Fig. 3c. Legend see Fig. 3a.

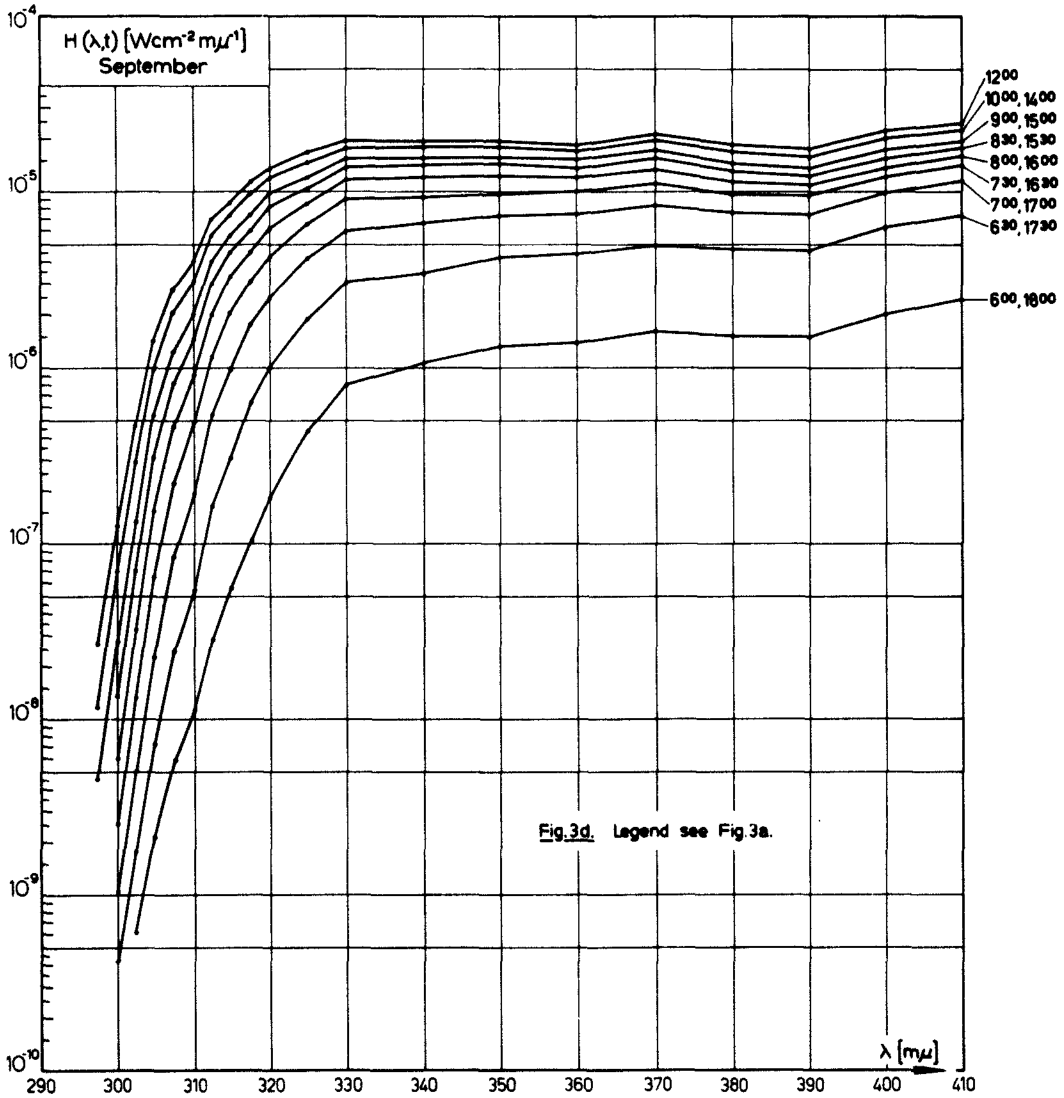

Fig. 3d. Legend see Fig. 3a.

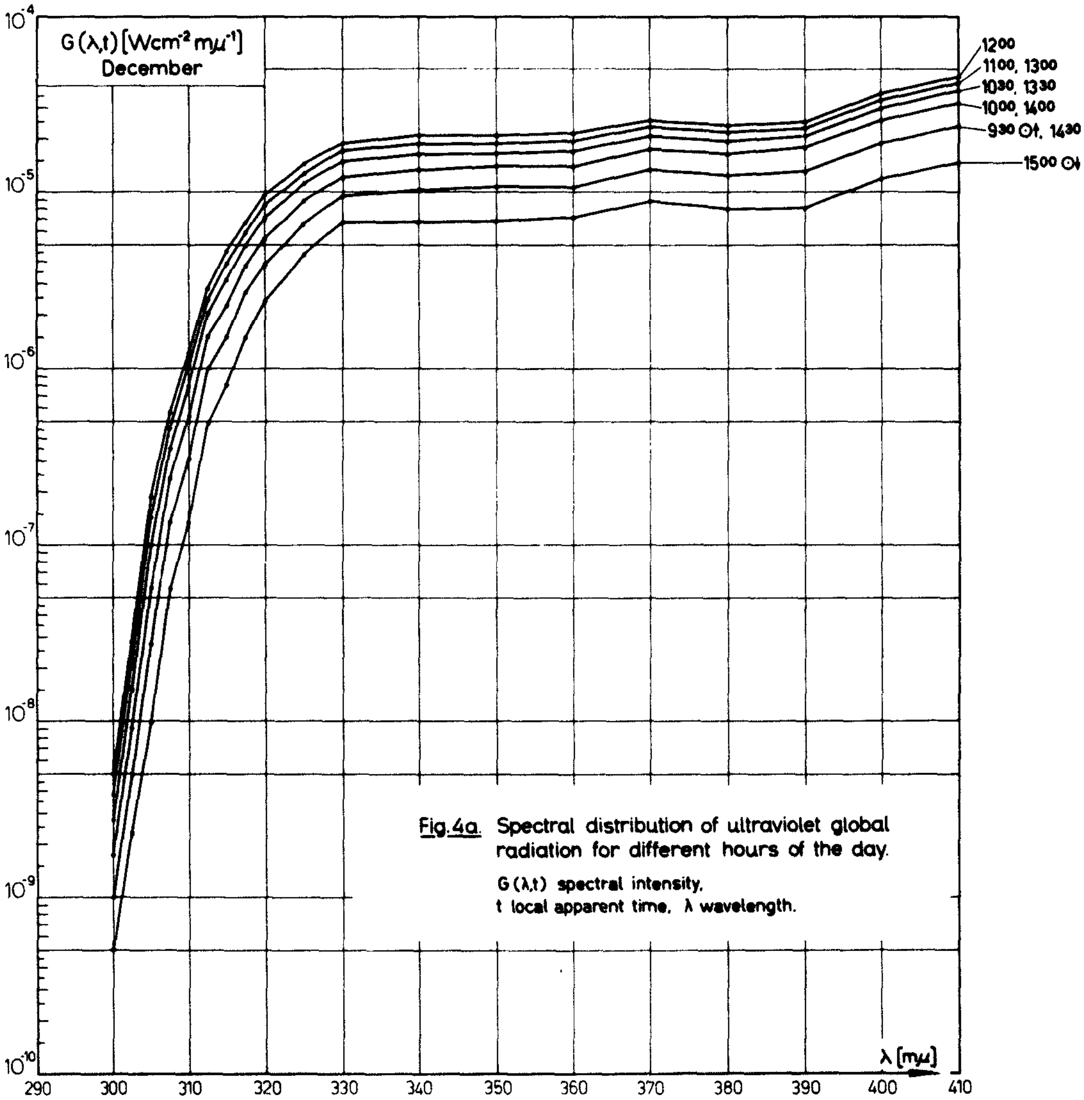

Fig.4a. Spectral distribution of ultraviolet global radiation for different hours of the day.

G (λ,t) spectral intensity,
t local apparent time, λ wavelength.

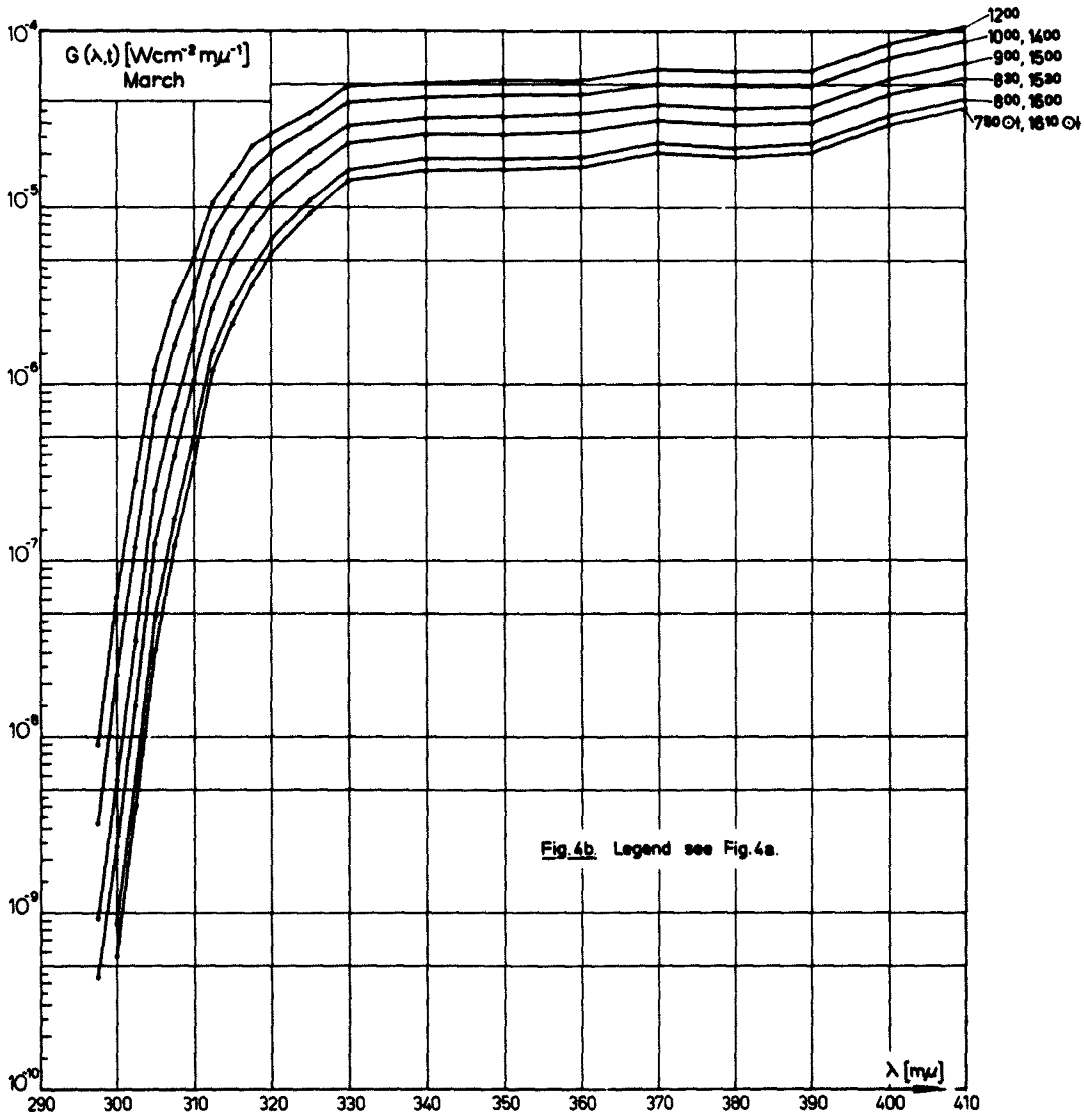

Fig.4b. Legend see Fig.4a.

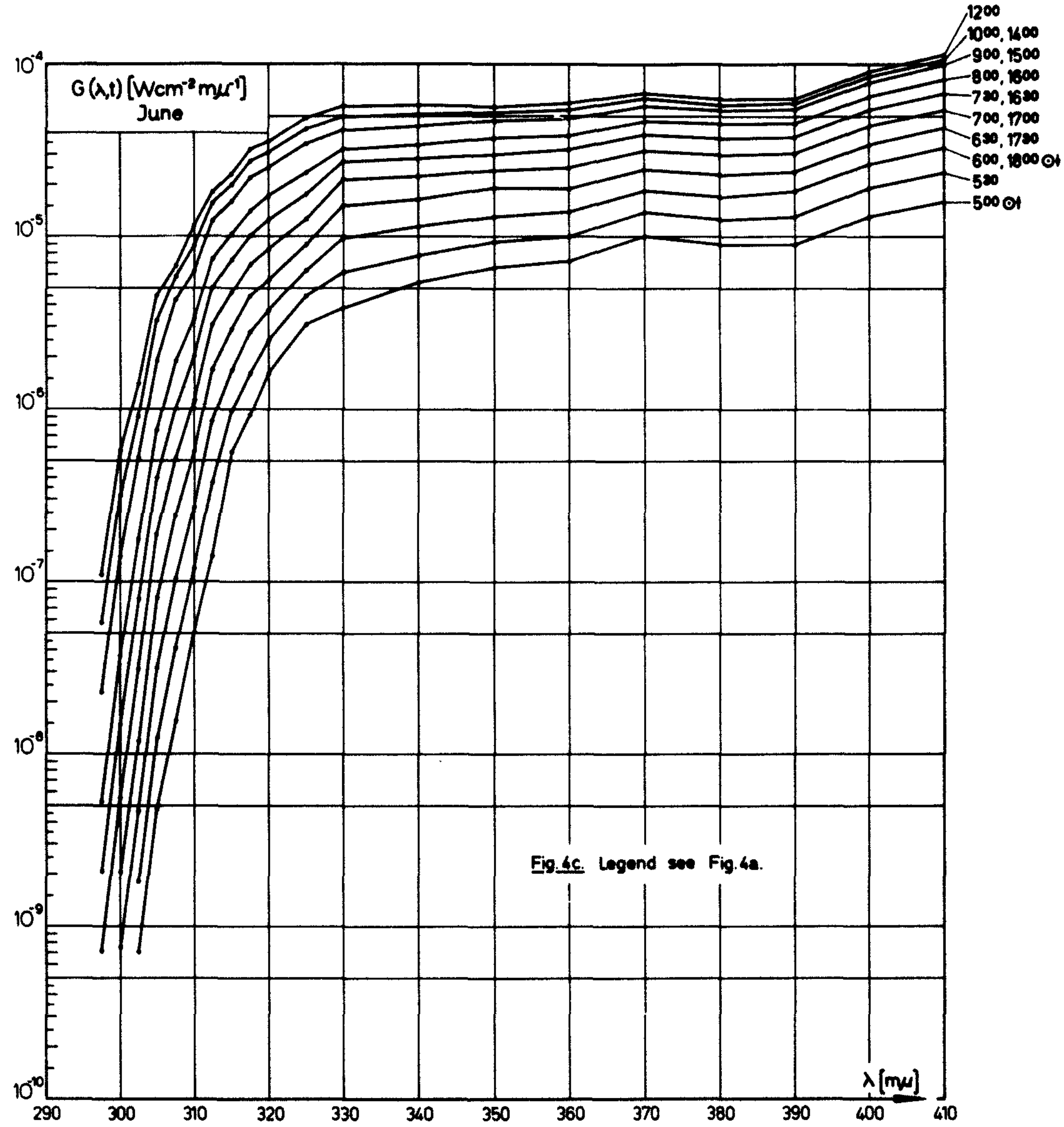

Fig. 4c. Legend see Fig. 4a.

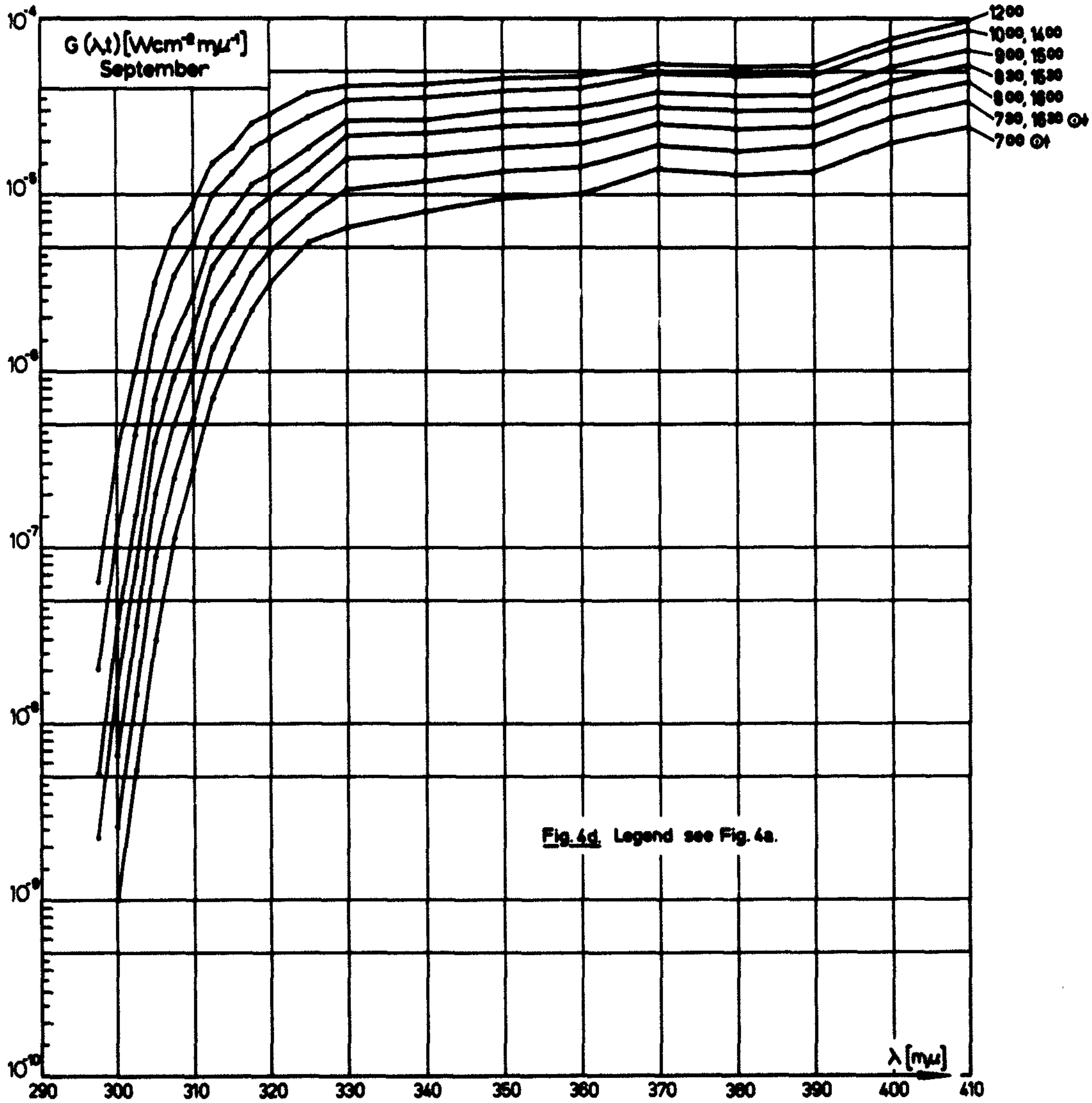

Fig. 4d. Legend see Fig. 4a.

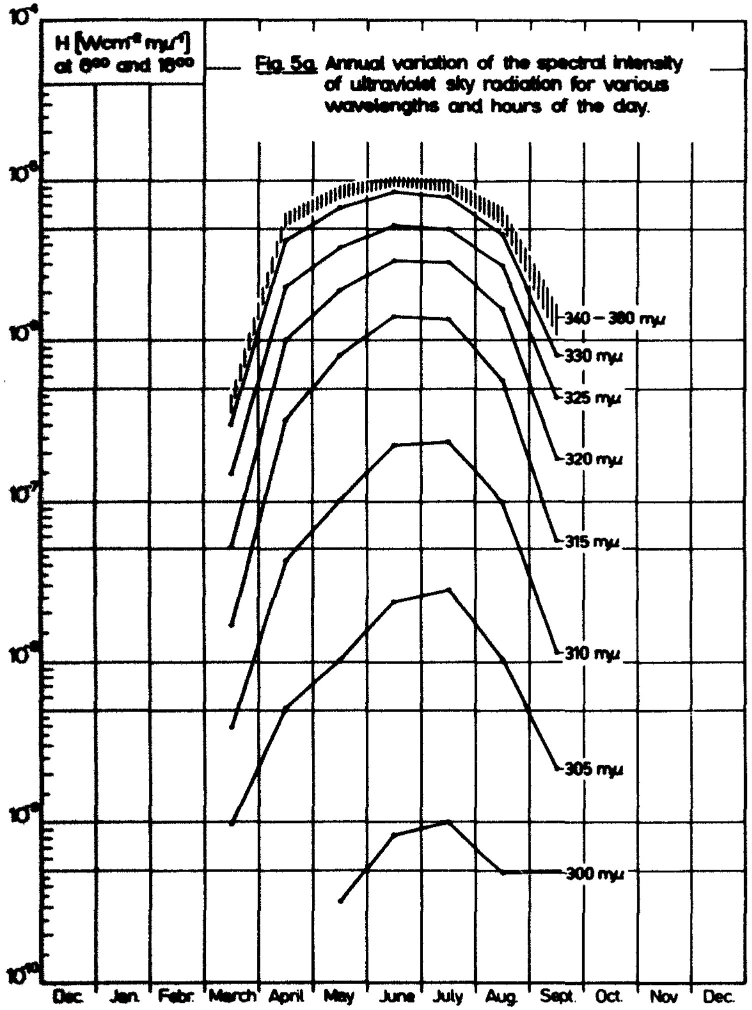

Fig. 5a. Annual variation of the spectral intensity of ultraviolet sky radiation for various wavelengths and hours of the day.

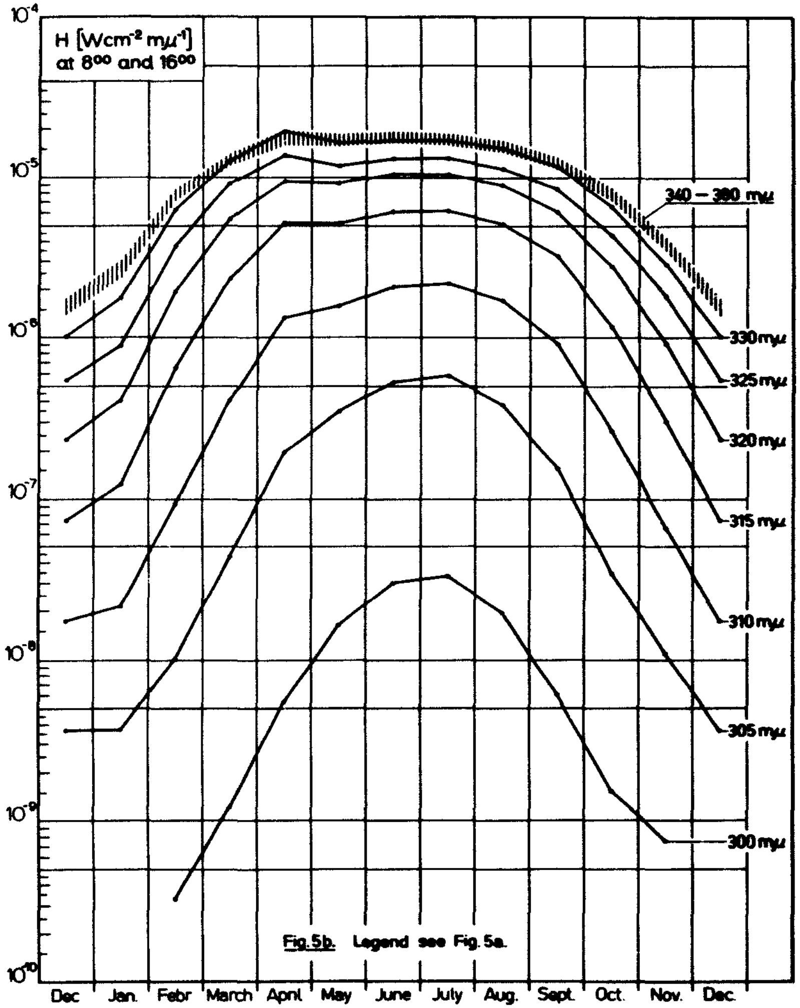

Fig. 5b. Legend see Fig. 5a.

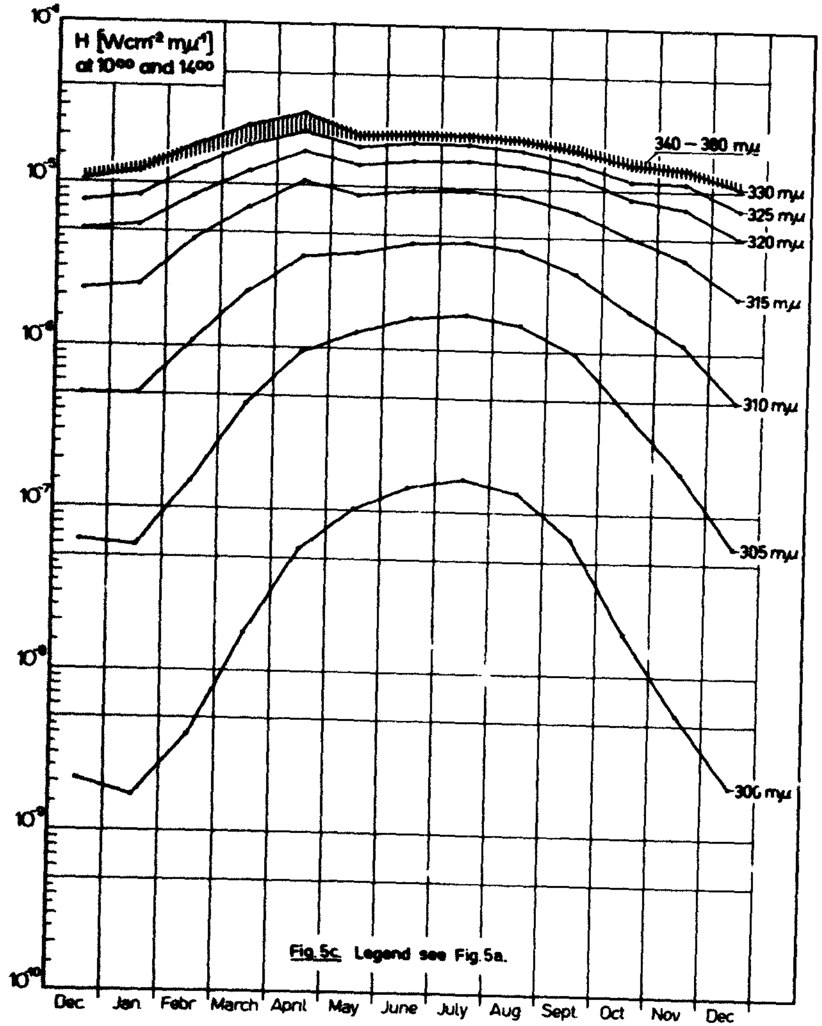

Fig. 5c. Legend see Fig. 5a.

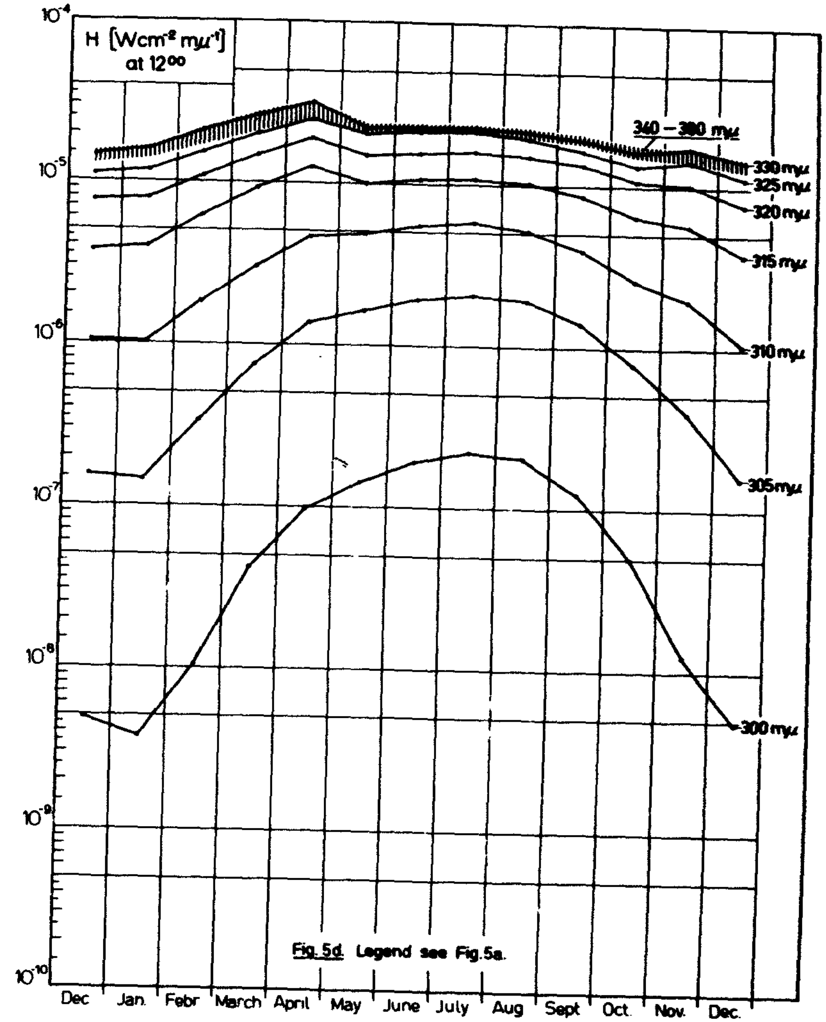

Fig. 5d. Legend see Fig. 5a.

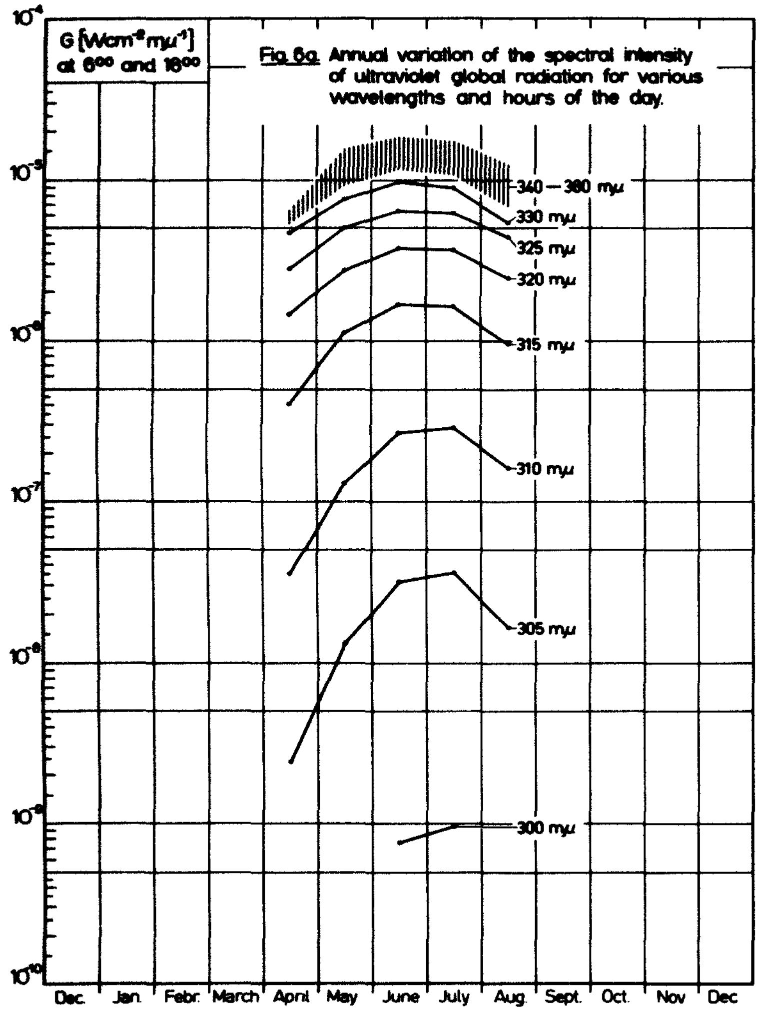

Fig. 6a. Annual variation of the spectral intensity of ultraviolet global radiation for various wavelengths and hours of the day.

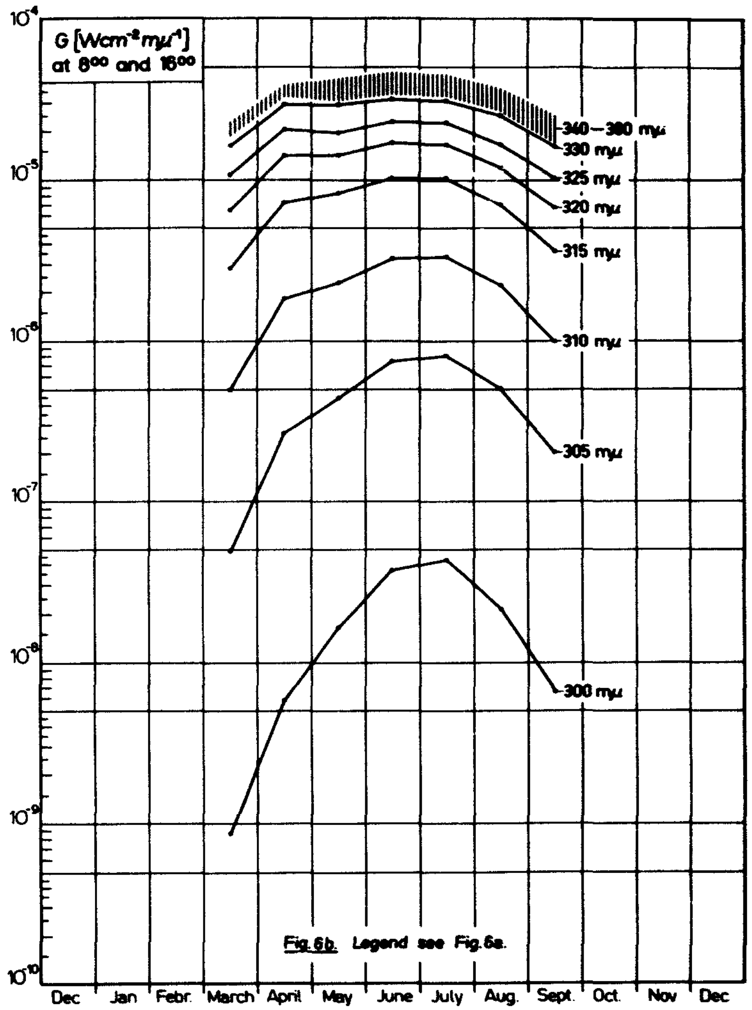

Fig. 6b. Legend see Fig. 6a.

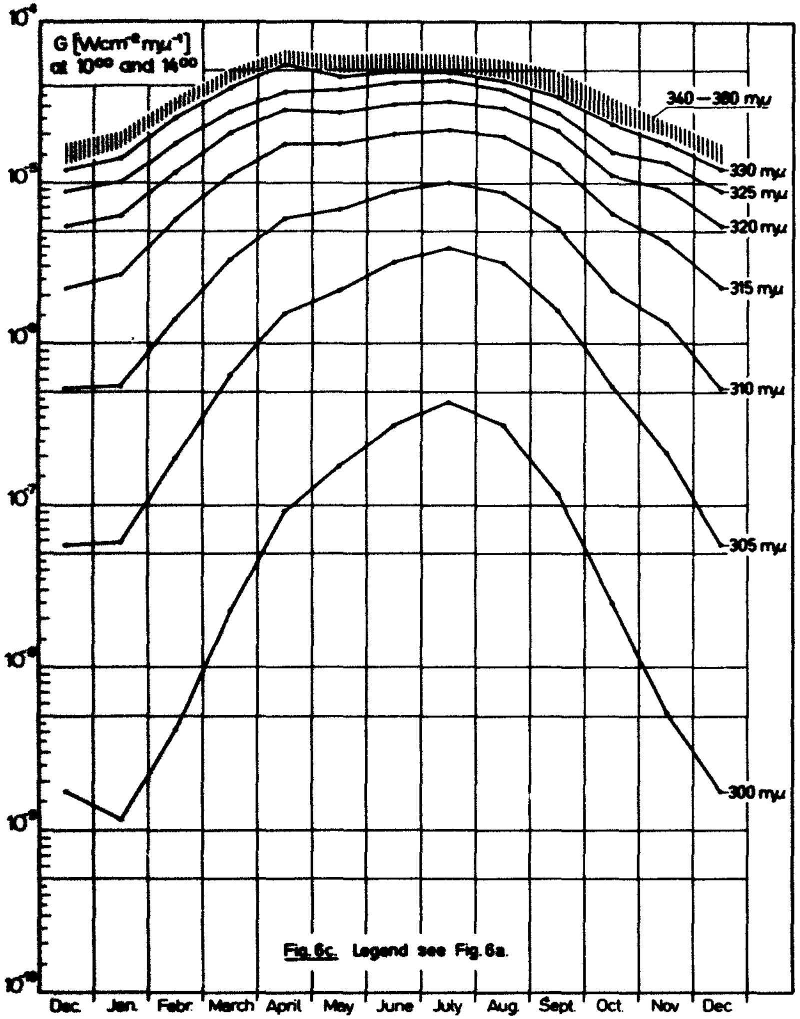

Fig. 6c. Legend see Fig. 6a.

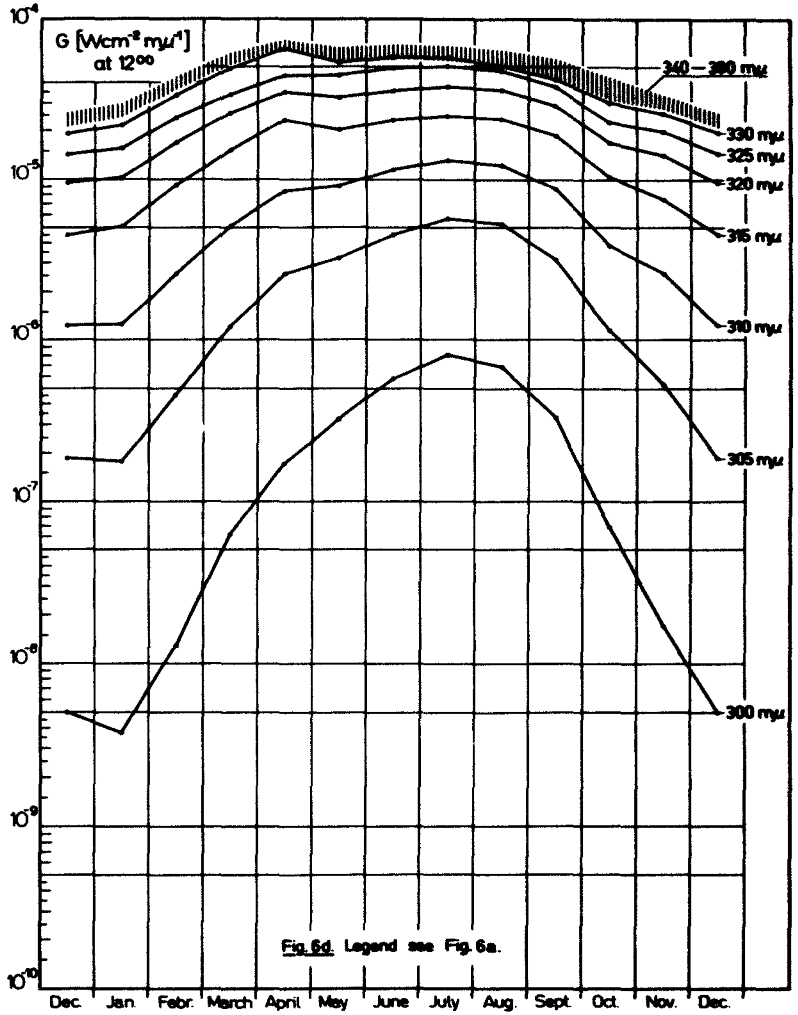

Fig. 6d. Legend see Fig. 6a.

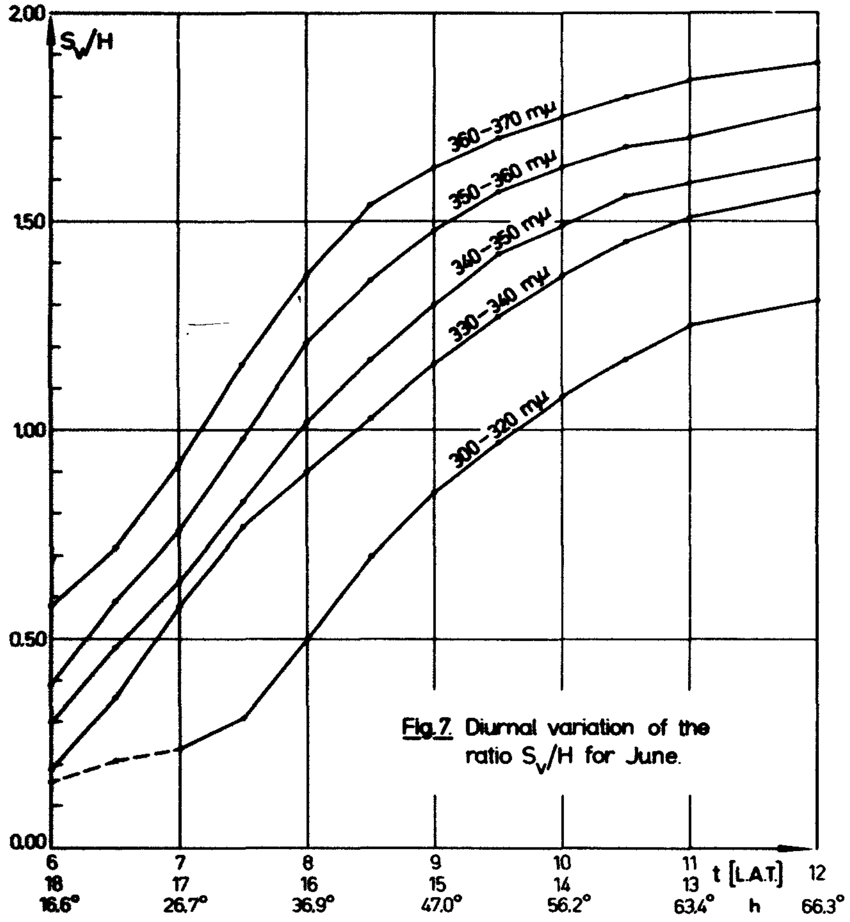

Fig.7. Diurnal variation of the ratio S_v/H for June.

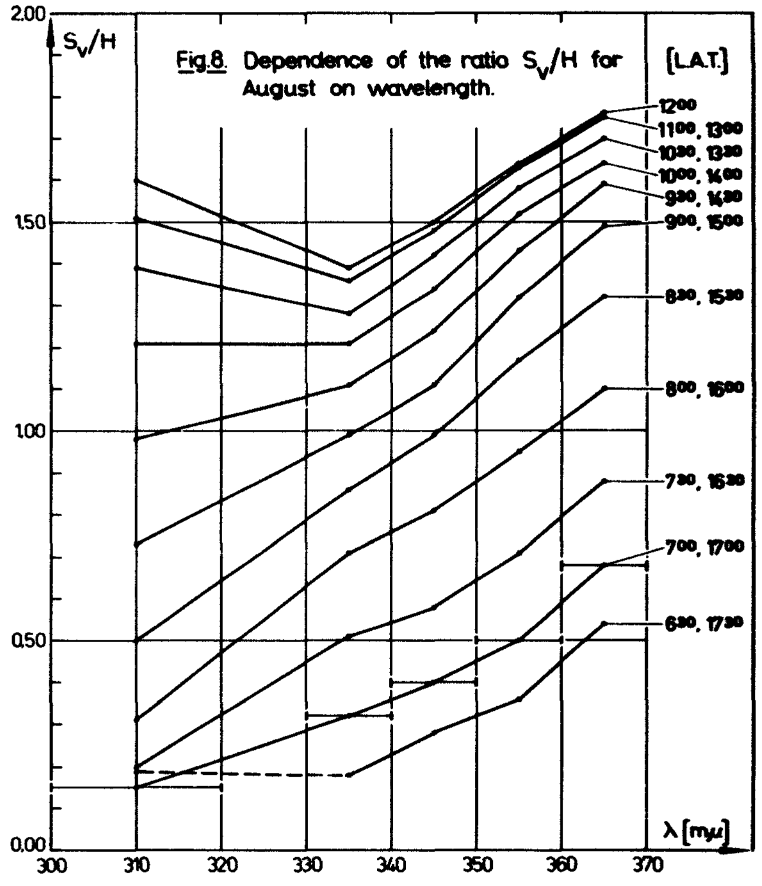

Fig.8. Dependence of the ratio S_v/H for August on wavelength.

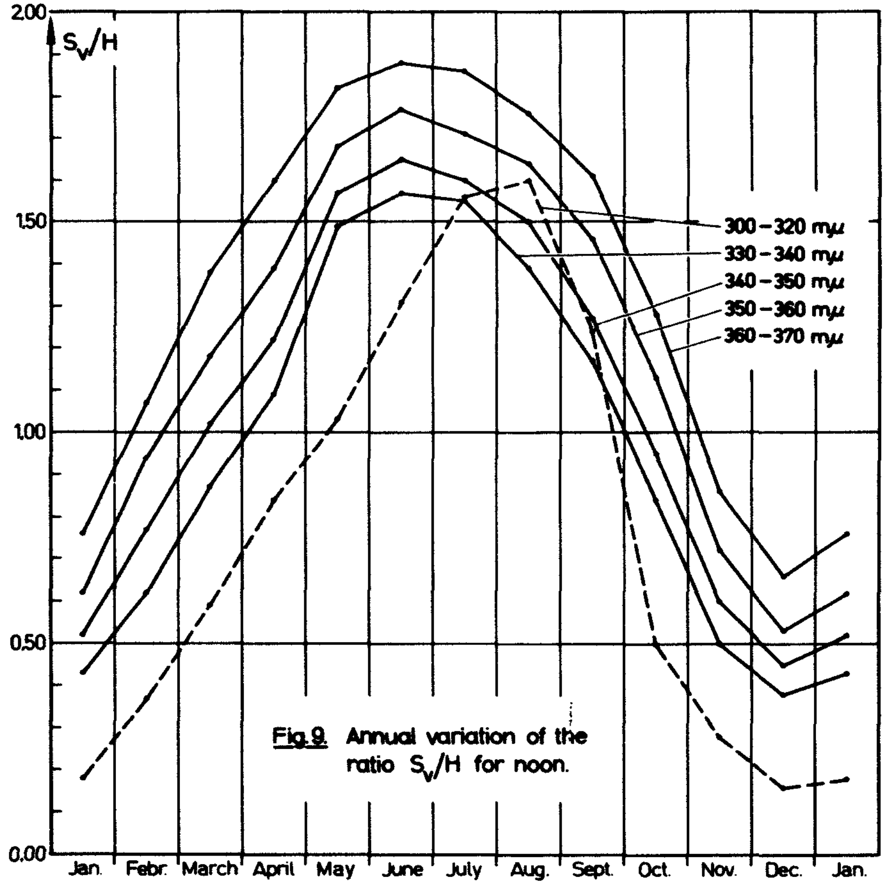

Fig. 9. Annual variation of the ratio S_V/H for noon.

PHYSIKALISCH-METEOROLOGISCHES OBSERVATORIUM DAVOS
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Hourly values of the spectral intensity of ultraviolet sky and global radiation are presented for every month of the year. These figures relate to monthly means of atmospheric ozone and to average conditions of albedo and turbidity during the winter and summer period. Diagrams showing the diurnal variation of the intensity for various wavelengths and its spectral distribution for different hours of the day are presented for December, March, June and September. Further diagrams show the annual variations of the intensity for various wavelengths and hours. The latter curves illustrate the combined effect of the annual variation of solar declination, atmospheric ozone and ground reflexion on the intensity. The ratio between the vertical component of direct ultraviolet solar radiation and total diffuse sky radiation in its diurnal and annual variation and in dependence on wavelength is examined.

No climatological means in a strict statistical sense are given. The diurnal and annual variations of intensity have been computed from the relations between intensity, solar altitude and atmospheric ozone established in Technical Summary Report No.1, Contract AF 61(052)-64. A description of the applied procedure and a discussion of the results and their accuracy is added to the tables and diagrams.

UNCLASSIFIED

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2. Spectral distribution of ultraviolet sky and global radiation
3. Diurnal variation of uv.sky and global radiation
4. Annual variation of uv.sky and global radiation
5. The vertical component of direct uv.solar radiation in relation to the intensity of uv. sky radiation

Bener, P.

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